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DEPARTMENT OF HEALTH AND ENVIRONMENTAL SCIENCES

WATER QUALITY BUREAU

MONTANA SEDIMENT AND EROSION CONTROL MANUAL

Prepared by

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MPDES Storm Water Program

May 1993

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MONTANA SEDIMENT AND EROSION CONTROL MANUAL

This manual is designed to assist contractors, engineers and consultants with designing and implementing an Erosion Control Plan as required by a MPDES general permit for storm water discharges associated with construction activity. Many of the best management practices (BMPs) and erosion control concepts described in this manual may be applicable to activities other than construction (ie. mining sites, logging activities, agriculture, and small development or homeowner projects).

The term contractor is used consistently throughout the manual but can be interpreted to mean engineer, project manager, consultant, developer, landowner or planner depending on the situation.

This manual was designed after EPA's Draft Storm Water Pollution Prevention for Construction Activities and material from EPA's publication has been borrowed and referenced whenever possible. For additional reference material, see the following page.

1st Edition

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CHAPTER 1

INTRODUCTION

The Montana Pollutant Discharge Elimination System (MPDES) regulations (ARM 16.20.1314) requires a storm water discharge permit for construction activity in which clearing, grading and excavating will result in the disturbance of >5 acres total or the disturbance of >1 acre if located within 100 feet of a surface water body (stream, river or lake). A Storm Water Erosion Control Plan must be designed and approved by the Water Quality Bureau prior to construction taking place. The objective of the plan is to minimize erosion of disturbed areas during the construction and post construction phase of a project. The principles of an erosion control plan can be used for other construction, mining, etc. projects not requiring an MPDES permit for storm water but where erosion control is desirable.

The Erosion Control Plan should accomplish 3 main objectives: 1) The first objective is to limit the exposure of disturbed areas of a site to the shortest duration possible. 2) The second objective is to divert upslope runoff around or away from disturbed areas until such time as they are stabilized. 3) Lastly, the plan should address methods for the removal of sediment from the storm water before it leaves the site.

The following plan requirements are taken directly from the general permit language for storm water discharges associated with construction activity.

1.1 Erosion Control Plan Requirements

The plan shall be filed with the Water Quality Bureau 30 days prior to construction and a copy shall also be maintained at the construction site.

The plan may include the use of sediment basins, berms, barriers, filter strips, covers, diversion structures, seeding, sodding, and/or other control structures or best management practices (BMPs - See Chapter 3). Any plan which requires engineered structures, such as detention ponds or diversion structures, or which is prepared for a construction activity which includes 20 acres or more in total land disturbance, shall be prepared by a registered professional engineer. The erosion control plan shall include at least the following items:

1.2 Site Description

Each plan shall, at a minimum, provide a description of the

following:

1. The nature of the construction activity, including a proposed time table for major activities.

2. Estimates of the total area of the site, and all other sites if a phased development project, that is expected to undergo clearing, excavation, and/or grading.

3. A site map indicating areas of total development and, as a minimum, all areas of soil disturbance, areas of cut and fill, drainage patterns and approximate slopes anticipated after major grading activities, areas used for the storage of soils or wastes, location of all erosion control facilities or structures and areas where vegetative practices are to be implemented, the location of impervious structures (including buildings, roads, parking lots, outdoor storage areas, and etc.) after construction is completed, springs, wetlands and other surface waters, and the boundary of 100-year flood plains, if determined.

4. The nature of fill material to be used, the existing soils located at the site, and the erodibility of such soils. Soil surveys are good sources of soil erodibilities. The Soil Conservation Service, the Forest Service and the Bureau of Land Management produce soil surveys. If possible, include information on the soil series and/or mapping units found at the site.

5. The names of the receiving water(s) and the size, type and location of each outfall or, if the discharge is to a municipal separate storm sewer, a letter of approval from the municipality which authorizes use of the storm sewer and the location of any storm sewer discharge to public waters.

1.3 Controls/BMPs

The erosion control plan should contain a description of best management practices (BMPs) appropriate for the site which shall be implemented to control erosion. The following minimum components shall be addressed along with a schedule for implementation unless approved otherwise in writing by the Water Quality Bureau:

1. A description, including a schedule of implementation, of vegetative practices designed to preserve existing vegetation where practicable and revegetate open areas as soon as practicable after grading or construction. In developing vegetative practices, the operator shall consider: temporary seeding, permanent seeding, mulching, sod stabilization, vegetative buffer/filter strips, grassed waterways, erosion control blankets and tree and shrub planting.

2. A description of structural practices which indicates how, to the degree practicable, the permittee will divert flows from exposed soil, store flows, or otherwise limit runoff from exposed areas of the site. In developing structural practices, the operator shall consider the appropriateness of: straw bale dikes, silt fences, earth dikes, brush barriers, drainage swales, check dams, subsurface drains, pipe slope drains, rock outlet protection, drain inlet and outlet protection, temporary drain diversions, sediment traps, temporary sediment basins, infiltration trenches or basins, and retaining walls. All temporary control structures, including silt fences and straw bale dikes, shall not be removed until permanent vegetation and site stabilization has taken place.

3. Graveled access entrance and exit drives and parking areas to reduce the tracking of sediment onto public or private roads may need to be used during the wet season (November thorugh May). All unpaved roads on the site carrying more than 25 vehicle trips per day should be graveled.

4. When trucking saturated soils from the site, either tight trucks should be used or loads shall be required to drain until drippage has been reduced to less than 1 gallon per hour before leaving the site.

Visible or measurable erosion which leaves the construction site is prohibited. Visible or measurable erosion is defined as:

1. Deposits of mud, dirt, sediment or similar material exceeding 1/2 cubic foot in volume in any area of 100 square feet or less on public or private streets, adjacent property, or into the storm and surface water system, either by direct deposit, dropping, discharge, or as a result of the action of erosion; or

2. Evidence of concentrated flows of water over bare soils; turbid or sediment laden flows; or evidence of on-site erosion such as rivulets on bare soil slopes, where the flow of water is not filtered or captured on the site using the techniques in the approved erosion control plan; or

3. Earth slides, mud flows, earth sloughing, or other earth movement which leaves the property.

NOTE - Under no condition shall the sediment be washed into the storm sewers or drainageways. Under no condition shall sediment discharge to surface waters or natural wetlands.

1.4 Pollutants Other Than Sediment

Contractors will also need to address controls for the following pollutants: oils, grease, paints, fuel (gasoline and diesel), concrete truck wash down areas, raw materials for manufacturing concrete (sand, aggregate, and cement), solvents, litter, debris and sanitary waste management. Storm Water Erosion Control Plans should also address the following:

1. Designate areas for equipment maintenance and repair.

2. Provide waste receptacles at convenient locations and provide regular collection of wastes.

3. Locate equipment washdown areas on site and provide appropriate control of washwaters. These activities should be conducted a minimum of 100 feet from surface waters.

4. Provide protected storage areas for chemicals, paints, solvents, fertilizers, and other potentially toxic materials.

5. Provide adequately maintained sanitary facilities.

CHAPTER 2

DESIGNING THE STORM WATER EROSION CONTROL PLAN

The Storm Water Erosion Control Plan is a requirement for MPDES storm water permit compliance and is the means for controlling pollutants in storm water discharges. Careful planning and proper implementation of the plan will lessen the likelihood of pollutants reaching state waters. A well thought out plan with schedules set for the various phases of construction will also assist the project manager or contractor with meeting time frame requirements for contract agreements.

Prior to designing an Erosion Control Plan, one must gather information about the site, determine the special requirements of the site, and then decide which BMPs will accomplish sediment and erosion control for the site. Therefore, the major steps in developing the plan are:

1. Site Evaluation and Preliminary Design Development

2. Site Assessment

3. BMP Selection/Final Plan Design

2.1 Site Evaluation and Preliminary Design Development

During the site evaluation and preliminary design development phase of an Erosion Control Plan, information is collected about site characteristics, a site map delineating important features is prepared, and the beginning phase of the design takes place.

Collecting Site Information

Before a plan can be designed for sediment and erosion control, information must be collected concerning the different characteristics of a site such as the size of the site, the soils found at the site, the drainage pattern for runoff, rainfall data, the nearest receiving water, and groundwater information if infiltration BMPs are planned.

Site Characteristics

The first step in getting started with an Erosion Control Plan is to collect information about the site where development will take place. Obtaining a map or an aerial photograph of the site provides a place from which to start. Aerial photographs of 4"/mile or 8"/mile are very good for planning purposes. If

possible, a topographic map, to scale, should be used. The map or photo should indicate existing land use, the location of surface waters, and the existing land use adjacent to the site. Examples of land use are buildings, pavement, agriculture, range, or forestry. Examples of surface waters are streams, rivers, lakes, springs, or wetlands.

The best site map is one that is developed from surveying the site (EPA, 1992). However, survey information may not be available or may be impractical. US Geological Survey topographical maps (quads) can be utilized to assist with designing a site specific map. However, USGS quad maps aren't very good as a final site map due to the large scale (1:24,000). Site features can not be adequately delineated on a map of this scale. But topographical features such as drainages, hills, depressions, etc. can be located from a USGS quad for developing a site map.

Aerial photographs are the best tools for planning purposes. They adequately locate surface features and land use activity plus they can be obtained at different scales. Sources of aerial photographs are the Agricultural Stabilization and Conservation Service (ASCS), the Soil Conservation Service (SCS), and the Forest Service (FS). Aerial photographs will have to be ordered so this will need to be taken in account during the planning process.

Soils Information

Erosion and sediment transport are directly related to the types of soils found at a site. Therefore, information on soil textures and erodibility is essential in designing and selecting the proper BMPs to be used at a site. The best soil information is that collected from borings at the site by a qualified soil scientist. The SCS may have soil survey information available for a site. In some cases the SCS will survey a site if it is requested in an area that has a soil survey staff. SCS soil survey information is excellent information for determining soil textures and erodibility. The SCS may also be able to assist planners with proper BMP selection for the soils present at a site.

If the site is located within a forest boundary, the USDA Forest Service may also have soil survey information or a soil scientist on staff who can assist planners. The Bureau of Land Management (BLM) may also have this information for land within their jurisdiction.

Drainage Patterns

The drainage patterns for a site are the different pathways that storm water runoff will flow on or off of a site. Drainage patterns should be indicated on the site map by placing arrows pointing in the direction of flow. Drainage patterns can be determined by using topographic maps, survey information, aerial

photos or by walking the site and observing the direction runoff would flow or has taken in the past. The size of each drainage area (if there is more than one at a site) will be needed for proper design of some BMPs.

Rainfall Data

Rainfall data is important information needed when designing certain BMPs such as sediment basins, detention/retention ponds, diversion ditches, etc. Most pond or catch basin structures are designed for the expected runoff from a site based on the soil texture, the slope, size of the drainage area, and the expected duration of a storm event. For example the 25 year/24 hour rainfall event is commonly used for sediment basin design. [Need to find where contactors can get this information.]

Receiving Water

The name , location and distance of nearby receiving waters from the site will need to be obtained. This information should be included on the site map. Receiving waters in Montana include streams, rivers, lakes, springs, and wetlands. Streams which only flow in the spring or once every 2-3 years should be identified as well. For projects which will involve a discharge to a Municipal Separate Storm Sewer System, the municipality will need to be notified. Documentation that the municipality has been notified will be required.

Groundwater Information

For projects located in areas where the groundwater is <10 feet below the ground surface (bgs), depth to groundwater should be obtained and reported. Coarse soils and high water tables provide a greater potential for groundwater pollution. If infiltration BMPs are going to be used, depth to groundwater should be reported and the location and number of drinking wells in close proximity to the site should be identified.

A general rule of thumb for protecting groundwater is infiltration practices should not be used in areas where the water table is <6 feet bgs and the soil textures are sand, loamy sand, sandy loam and/or coarse fragment content is >35 percent. Contact the WQB concerning proper BMP selection if groundwater is 6 feet or closer to the surface.

Sources of information on depth to groundwater are the Department of Natural Resources and Conservation (Water Resources Division), the Montana Bureau of Mines and Geology, or the US Geological Survey (Water Resources Division).

Develop a Preliminary Plan

After the above information has been collected, a preliminary site plan can be developed for the project. The preliminary site plan will need to consider the following items:

1) Disturb the smallest area possible to accomplish the project. If it is a large project, consider small areas for disturbance and develop the site in phases.

2) Keep the amount of cut and fill to a minimum. The larger the cut and fill, the greater the surface area from which erosion can take place.

3) Avoid disturbing sensitive areas if at all possible. Sensitive areas include: steep or unstable slopes, areas in or around surface waters, and areas with highly erodible soils.

4) For areas that must be disturbed to complete the project, divert runon from above the area to a more stable location such as a grassed swale, sediment pond, level spreader, etc. until the area is stabilized with vegetation or erosion control blankets. Stabilize disturbed areas as soon as practical with vegetation or erosion control measures.

5) For storm water that will discharge from the site, use some BMPs to remove pollutants prior to the discharge from the site (see Chapter 3, Best Management Practices).

A narrative description of the project can be completed at this time. The narrative description will describe the nature of the construction activity (ie. subdivision, highway project, industrial development, etc.), the area that will undergo disturbance, the project length, and a rough schedule for various activities (see Chapter 1.2 item 3).

Activities which should be discussed include clearing and grading, excavating and stockpiling, demolition, equipment maintenance and fueling areas, chemical storage and use, BMPs, and soil hauling procedures.

Prepare Construction Site Map

The construction site map can be started based on the information collected earlier and the nature of the project. The Construction Site Map should include the total area of the site, the area that will undergo disturbance, the approximate slopes after grading, and the final drainage pattern of the site.

2.2 Site Assessment

Material collected during the site evaluation is used to make

calculations for future use in deciding the needs of the site and the project. The site assessment phase of developing the plan involves measuring the site area, measuring the drainage areas, calculating the runoff coefficient, and calculating runoff rates and volumes of storm water if diversion or detention/retention structures are to be used.

Measure Site Area

The area of the total site to be developed should be measured to the nearest tenth of an acre (if this information is not already known). The area that will undergo disturbance should be measured also.

Methods for measuring the site include the use of a planimeter or the grid method. A planimeter is a device for measuring the area of a drawing or photo by tracing its outline and then calcualting the area. The grid method involves the use of grids of a known size placed on transparencies or graph paper. The transparency or graph paper is then placed over the site map and the grids are counted for the site. The area is determined from the number of grids counted.

Measure the Drainage Areas

The size of each drainage area should be determined and measured for each point where concentrated flow will leave the site or need to be treated, diverted or contained with BMPs. This information can be used to calculate runoff volumes and determine the best BMPs for use at the site.

Determine the Runoff Coefficient

The runoff coefficient (c) is the percent of rainfall or snowmelt that will result in runoff. Rainfall or snow melt at a site will have a certain percent that enters the ground (infiltrates), evaporates, is adsorbed by plants or other substances, and leaves the area as runoff. Impervious surfaces will have higher "c" values than more permeable surfaces. See the Appendix for typical "c" values for a number of land uses.

Many sites will have more than one type of land use. For such sites a weighted average of the "c" value will need to be calculated. See the Appendix for instructions on Calculating a "Weighted c".

Calculating Runoff Volumes

There are several methods used for calculating runoff rates and volumes. There are even various computer programs that can generate this information. Peak runoff rates can be calculated using the Rational Method, the SCS Method, or with runoff hydrographs for a

watershed. The SCS has developed a widely used method for calculating runoff volumes from one or more storms. The majority of methods used for estimating storm water runoff volumes are based on rainfall data, infiltration rates or losses, interception, adsorption, and/or losses to storage (Schwab and Frevert, 1985).

Contractors will need to calculate runoff volumes for each drainage area where storage BMPs will be used. An explanation of the method used to calculate the volumes should be included in the plan.

Sources of information on the above mentioned methods are:

Schwab, Glenn O. and Frevert, Richard K. Elementary Soil and Water Engineering. 3rd ed., John Wiley & Sons, New York, 1985.

USDA Soil Conservation Service (1979). Engineering Field Manual for Conservation Practices. Washington, D.C.

USDA Soil Conservation Service (1972). National Engineering Handbook. Washington, D.C.

2.3 BMP Selection/Final Plan Design

The next step is to begin selecting the best management practices (BMPs) to be used at the site to control sediment and erosion along with other pollutant sources. Decisions will now be made in order to meet storm water pollution prevention requirements and still accomplish the construction of the project. The BMPs selected for storm water control will be finalized into a plan which will meet the following requirements (EPA, 1992):

1. Sediment and Erosion Controls
2. Storm Water Management Controls (post construction)
3. Controls for Pollutants Other than Sediment
4. Location of Controls Indicated on the Site Map
5. Inspection and Maintenance Schedule
6. Coordinate Installation of BMPs with Construction Activity
7. Submit Plan for State Approval

Sediment and Erosion Controls

A number of best management practices (BMPs) for sediment and erosion control have been evaluated for their effectiveness. Many

of these practices have been in use for many years in the agricultural and silvicultural fields. Some practices are vegetative, some are structural, and some are designed to control runoff volumes and/or pollutant removal. Many of these practices can be used on a temporary basis while others will become permanent controls.

Chapter 3 describes the BMPs that can be used at construction sites as well as design features. These BMPs are most effective when used in combination to reach the goal of pollutant reduction. Proper design, installation and maintenance will also be important items in order for BMPs to be effective.

Storm Water Management Controls

Storm water management controls are used after the construction is completed to insure surface waters will not be degraded. These controls are also discussed in Chapter 3. Some examples are retention/detention ponds, infiltration basins or trenches, or possibly man-made wetlands. The management controls used at a site will depend on the site specific requirements of slope, soil textures, size of the site, drainage patterns, expected runoff volumes, etc.

Controls for Pollutants Other Than Sediment

Construction sites use a variety of materials which may also pollute storm water runoff. The substances of concern are oil and grease from various equipment, fuel, paints or stains, solvents, litter, raw material storage, aggregate storage practices, debris and sanitary waste management. The following items should also be incorporated into the Storm Water Erosion Control Plans:

1. Designate areas for equipment maintenance and repair. What good housekeeping practices will be used to prevent soil and water contamination? These same items will need to be addressed for fueling areas also.

2. Provide waste receptacles at convenient locations and provide regular collection of wastes. Waste disposal should address protection from the wind (waste scattered by wind) as well as storm water runoff.

3. Equipment washdown areas will need to be located on site and appropriate control of washwater will need to be addressed. Sediment should not be allowed to leave the site on vehicle tires or spills from hauling operations onto local roads where material can wash into nearby surface waters.

4. Protected storage areas should be provided for chemicals, paints, solvents, fertilizers, fuel, and any other potentially toxic materials. Storm water should not be allowed to come

into contact with these types of materials.

5. Provide adequately maintained sanitary facilities.

Location of Controls Indicated on the Site Map

The final site map for the Erosion Control Plan should indicate the location of BMPs to be used during and after construction, areas listed above where activities of concern will take place, drainage patterns, slopes after grading, areas that will be disturbed, diversion structures, etc. A legend indicating the symbols used for sediment and erosion control practices as well as storm water management controls should be included on the map. See the BMP specifications section for standard BMP symbols.

The major items which should be indicated on the final map are (EPA, 1992):

* Drainage patterns and drainage boundaries
* Approximate slopes after grading
* Areas of Soil Disturbance
* Areas where potential polluting activities will take place or materials will be stored
* Surface waters
* BMPs and storm water management controls
* Location of paved areas, buildings, and gravel or vegetated areas

The following are some vegetative practices for sediment and erosion control:

temporary seeding	erosion control blankets
permanent seeding	mulching
sod stabilization	vegetative buffer strips
grassed waterways	tree and shrub planting
preserving existing trees	

The following are some structural practices for controlling sediment and erosion:

straw bale dikes	silt fences
earth dikes	brush barriers
drainage swales	check dams
subsurface drain	pipe slope drain
temporary drain diversion	drain inlet protection

level spreaders	sediment traps
temporary sediment basins	infiltration basins
rock outlet protection	retaining walls
terracing slopes	

The following are some storm water management practices for controlling sediment and runoff:

1. Infiltration of runoff on-site, ie. infiltration trenches or basins.
2. Flow attenuation by use of vegetative waterways and natural depressions.
3. Storm water retention structures, ie. wet ponds or man-made wetlands.
4. Storm water detention structures, ie. dry ponds.

Inspection and Maintenance Schedule

A MPDES permit for storm water discharges associated with construction activity requires routine inspection and regular maintenance of BMPs. BMPs must be regularly maintained in order for them to be effective and accomplish the task they are designed for. The general permit for storm watr discharges associated with construction activity requires the following monitoring requirements:

1. All erosion control facilities shall be inspected by or under the direction of the contractor at least once every seven calendar days and within 24 hours after any storm event of greater than 0.5 inches of rain per 24 hour period.

2. During stormy periods or periods of snow melt when runoff occurs daily, all erosion control facilities shall be inspected by or under the direction of the contractor daily.

3. Storm water runoff discharges shall be visually monitored at the above frequency to evaluate the effectiveness of the pollution control facilities or practices.

An inspection schedule should be designed to meet the general permit requirements. The person who will be responsible for completing the inspections and keeping adequate records should be identified in the plan as well.

Coordinate Installation of BMPs with Construction Activity

Once a contractor has determined which erosion control practices will be used at a site, the installation of these practices will need to be scheduled properly into the construction project. Most contractors already use 2 main construction scheduling methods, Critical Pathway and Bar Chart scheduling. Both of these methods

are based on a sequence of major activities which are required to complete the project. The erosion control practices (BMPs) will need to be scheduled or timed correctly based on these major activities. EPA suggests keeping the following general principles in mind when developing the sequence of major activities:

1. Downslope and sideslope perimeter controls should be installed before the land disturbing activity occurs.

2. Do not disturb an area until it is necessary for construction to proceed.

3. Construction of infiltration measures should be delayed to the end of the construction project when upstream (and upslope) drainage areas have been stabilized.

4. Do not remove temporary perimeter controls until after all upstream (and upslope) areas are stabilized.

5. Stabilize slopes and revegetate disturbed areas as soon as practical.

Submit Plan for State Approval

Once the plan is finalized, it will need to be submitted to the Water Quality Bureau (WQB) for approval at least 30 days prior to construction taking place. The WQB will review the plan and approve it or comment on the deficiencies. It is best to submit the plan as early as possible to the WQB since plan deficiencies will need to be solved prior to construction taking place.

CHAPTER 3

STORM WATER RUNOFF BEST MANAGEMENT PRACTICES FOR SEDIMENT AND EROSION CONTROL

Erosion and subsequent sediment transport can have a significant impact on the water quality of receiving surface waters. Sediment loads to surface waters increase turbidity, increase water temperatures, degrade fish habitat and spawning areas, and depress dissolved oxygen concentrations. Moreover, toxic substances, trace metals and nutrients which are adsorbed to soil particles can be transported into surface waters as well. The addition of these substances to surface waters degrades the existing water quality and may reduce the survival of cold water fish species. Montana has many quality cold water fishing streams.

In an effort to protect existing water quality of the state's surface waters, a number of best management practices (BMPs) have been evaluated for controlling sediment and erosion from storm water runoff. Erosion generally is greatest in areas where the surface has been disturbed and the soil is exposed to rainfall events. BMPs for sediment and erosion control can be vegetative practices, structural practices or storm water management practices.

Some vegetative and structural practices can be used for areas in which temporary controls are needed. Temporary sediment and erosion control practices are generally used during the construction phase of a project or until permanent controls can be established. Many temporary controls can be developed into permanent practices after construction or disturbance activities are completed. Temporary sediment and erosion control practices include:

- temporary seeding
- mulching
- grassed waterways
- straw bale dikes
- sediment traps
- silt fences
- brush barriers
- erosion control blankets
- sod stabilization
- vegetative buffer or filter strips
- temporary drain diversions
- temporary sediment basin
- check dams

In most situations, a combination of BMPs are necessary to adequately control sediment and erosion. Moreover, these BMPs must be properly designed and maintained in order to be effective. Diversion and retention/detention structures should be designed by a Professional Engineer (PE) or other qualified individual.

Am important concept to keep in mind at construction sites is to limit the amount of time and the size of a disturbed area as much

as possible during construction. Limiting the amount of native vegetation removed and the amount of time that bare soil is exposed to erosive forces, will considerably reduce the amount of sediment in storm water runoff. This in turn will reduce the number of BMPs needed to control storm water at a site.

Since a certain amount of disturbance always occurs at construction sites, it is important that disturbed areas are stabilized as soon as possible. This concept is critical on slopes that exceed 15 percent or have extensive slope lengths. A carefully thought out schedule of activities for a site can minimize disturbance time. In instances in which the exposure of a slope can not be avoided, diversion practices are effective at minimizing runoff over a disturbed area. Dikes and ditches or a combination of the two can be effective for diverting runoff into more stable areas or sediment basins (See Figure II-2.3). Properly designed slope drains or slope stabilization practices can solve this problem as well.

In situations in which erosion is unavoidable, it is important that sediment is retained on-site. This can be accomplished by using BMPs which filter out sediment from the runoff or by using BMPs which retain the runoff until such time as the sediment settles out. Preventing erosion is always preferable to treatment after the fact.

Lastly, it is important to note that maintenance of BMPs is a must. A BMP monitoring and maintenance program will insure adequate sediment and erosion control. No matter how well designed or properly installed a BMP is, if its not maintained it may not be doing the job effectively.

3.1 BMP DISCUSSION

The BMP Glossary at the end of the manual briefly describes the best management practices, their purpose, and provides some mention of applicability. The BMP specifications section describes each BMP, advantages and disadvantages for use and provides design criteria for construction. The type and number or combination of BMPs needed to control erosion will depend on several factors such as soil texture, topography (slope steepness and length), size of the area disturbed or denuded, the frequency and intensity of rainfall events, and the distance to surface water features.

Long steep slopes which have highly erodible soils present will require a combination of BMPs such as mulching with temporary seeding and jute netting to hold the mulch and seeding in place. Erosion control blankets can be used with either temporary or permanent seeding to prevent sediment from leaving the construction site. If such a condition occurs on a cut slope, stair stepping the slope face in conjunction with temporary or permanent seeding

usually provides good protection. Keep in mind that the steeper the slope, the more protection will be required to control erosion.

Slopes that are <30% or have soils that have a slight to medium erosion hazard will not require the same protection as slopes mentioned previously. If these slopes aren't extensive in length, mulch that is crimped into the soil to hold it place may be sufficient. Temporary or permanent seeding may also be sufficient depending on the time of the year. Stair strepping or terracing these slopes may be sufficient until permanent seeding can take place.

The distance to surface waters (streams, rivers, lakes, wetlands) will also determine the type and number of BMPs that must be used. For example, if the project allows for the use of a 50 feet buffer zone on each side of these features, then fewer to no additional BMPs may be necessary depending on the situation. **Buffer zones are the easiest and most cost effective BMP that can be used to protect water quality.** Slopes >30% and 15 feet or less to surface water will require a higher degree protection to insure water quality is not degraded.

3.2 BMP Assessment

The following assessment is taken directly from the Metropolitan Washington Council of Governments' A Currant Assessment of Urban Best Management Practices, Executive Summary, p. 1-3. The Water Quailty Bureau feels this information will be quite useful in determining which BMPs will best accomplish pollution prevention goals for various sites.

This report is intended to define the capabilities and limitations of the current generation of urban best management practices (BMPs) in order to provide effective stormwater quality management. These capabilities and limitations are **extremely** important to keep in mind when developing strom water management programs (or plans).

The following information provides a comparative assessment of eleven different BMP options.

* **Not all urban BMPs can reliably provide high levels of removal for both particulate (sediment) and soluble pollutants.** Effective BMPs include wet ponds, storm water wetlands, multiple pond systems and sand filters. Infiltration BMPs are presumed to be effective in removing pollutants, but are not reliable given their poor longevity. Infiltration BMPs, such as grassed swales, filter strips and water quality inlets, cannot provide reliable levels of pollutant removal until their basic design is significantly enhanced.

* **The longevity of some BMPs is limited to such a degree that**

their widespread use is currently not encouraged. Of particular concern are infiltration practices, such as basins, trenches and porous pavement. The poor longevity of these BMPs is attributable to a number of factors: lack of pretreatment, poor construction practices, application to infeasible sites, lack of regular maintenance, and in some cases, fundamental difficulties in basic design. Very often the life-spans of BMPs can be increased to acceptable lengths if local communities (contractors) adopt enhanced designs and commit to strong maintenance and inspection programs.

* **BMP options are adaptable to most regions of the country with the exception of extremely arid regions of the West and the colder climates of the North.** In these regions, conventional BMP designs may need to be refined to account for high evaporation rates or subfreezing snowmelt conditions, respectively. New BMP options should also be explored.

* **No single BMP option can be applied to all development situations and all BMP options require careful site assessment prior to design.** Pond options are applicable to the widest range of development situations, but typically require a minimum drainage area. On the other hand, infiltration practices have very limited applications, requiring field verification of soils, water tables, slope and other factors.

* **Several BMPs can have significant secondary environmental impacts, although the extent and nature of these impacts is uncertain and site-specific.** Pond systems, which offer reliable pollutant removal and longevity, tend to be associated with the greatest number and strongest degree of secondary environmental impacts. Careful site assessment and design are often required to prevent stream warming, natural wetland destruction and riparian habitat modification.

* **Relatively limited cost data exists to aid in the assessment of the comparative cost-effectiveness of urban BMP options.** Presently, the selections of BMPs is based more on longevity, feasibility, and local design factors than on comparative cost. It is expected that construction costs for all BMPs will increase in the future due to the enhanced designs needed for more reliable pollutant removal and longevity. Costs may also increase in response to increasingly complex permitting requirements. Maintenance costs may rival construction costs over the design life of many BMPs; however, many jurisdictions currently do not have very active BMP maintenance programs.

* **Many of the conventional urban BMPs need to be enhanced to provide more reliable pollutant removal and greater longevity.** In many cases systems approach to BMP design is warranted whereby multiple techniques for runoff attenuation, conveyance, pretreatment, and treatment are utilized.

* **Several fundamental uncertainties still exist with respect to urban BMPs and need to be resolved through basic research.** These uncertainties include the toxicity of residuals trapped within BMPs (both ponds and infiltration); and the long-term performance of urban BMPs.

3.3 BMP Specifications for Design

The following BMP specifications are borrowed from The Storm Water Management Manual for The Puget Sound Basin and have been edited for use in Montana. These specifications will be considered standard for use in complying with the storm water regulations. For highway construction projects, Montana Department of Transportation specifications will be used for all MDT projects. Other specifications may be used such as those used by the Soil Conservation Service, the Forest Service or the Bureau of Land Management. Specifications for BMPs other than stated in this manual will need to be submitted with the Erosion Control Plan for MPDES storm water permit requirements.

TEMPORARY SEEDING OF STRIPPED AREAS

Symbol:

Definition:

The establishment of a temporary vegetative cover on disturbed areas by seeding with appropriate rapidly growing annual plants.

Purpose:

To provide temporary soil stabilization by planting grasses and legumes to areas which would remain bare for more than 7 days where permanent cover is not necessary or appropriate.

Conditions Where Practice Applies

- Permanent structures are to be installed or extensive re-grading of the area will occur prior to the establishment of permanent vegetation.
- Areas which will not be subjected to heavy wear by construction traffic.
- Areas sloping up to 10% for 100 feet or less.

Advantages

1. This is a relatively inexpensive form of erosion control but should only be used on sites awaiting permanent planting or grading. Those sites should have a permanent measure used (see BMP BMP, Permanent Seeding and Planting).
2. Vegetation will not only prevent erosion from occurring, but will also trap sediment in runoff from other parts of the site.
3. Temporary seeding offers fairly rapid protection to exposed areas.

Disadvantages/Problems

1. Temporary seeding is only viable when there is a sufficient window in time for plants to grow and establish cover. During the establishment period the bare soil should be protected with mulch and/or clear plastic covering.
2. If sown on subsoil, growth will be poor unless heavily fertilized and limed. Because over-fertilization can cause pollution of storm water runoff, other practices such as mulching alone may be more appropriate. The potential for over-fertilization is an even worse problem in or near aquatic systems.
3. Once seeded, areas cannot be used for heavy traffic.
4. May require regular irrigation to flourish. Regular irrigation is not encouraged because of the expense and the potential for erosion in areas that are not regularly inspected. The use of low

maintenance native species should be encouraged, and planting should be timed to minimize the need for irrigation.

Planning Considerations

Sheet erosion, caused by the impact of rain on bare soil, is the source of most fine particles in sediment. To reduce this sediment load in runoff, the soil surface itself should be protected. The most efficient and economical means of controlling sheet and rill erosion is to establish vegetative cover. Annual plants which sprout rapidly and survive for only one growing season are suitable for establishing temporary vegetative cover. Temporary seeding is effective when combined with construction phasing so bare areas of the site are minimized at all times.

Temporary seeding may prevent costly maintenance operations on other erosion control systems. For example, sediment basin clean-outs will be reduced if the drainage area of the basin is seeded where grading and construction are not taking place. Perimeter dikes will be more effective if not choked with sediment.

Temporary seeding is essential to preserve the integrity of earthen structures used to control sediment, such as dikes, diversions, and the banks and dams of sediment basins.

Proper seedbed preparation and the use of quality seed are important in this practice just as in permanent seeding. Failure to carefully follow sound agronomic recommendations will often result in an inadequate stand of vegetation that provides little or no erosion control.

Design Criteria

- Time of planting - Planting should preferably be done between April 1 and June 30, and September 1 through October 31. If planting is done in the months of July and August, irrigation may be required. If planting is done between November 1 and March 31, mulching shall be required immediately after planting. If seeding is done during the summer months, irrigation of some sort will probably be necessary.

- Site preparation - Before seeding, install needed surface runoff control measures such as gradient terraces, interceptor dike/swales, level spreaders, and sediment basins.

- Seedbed Preparation - The seedbed should be firm with a fairly fine surface. Perform all cultural operations across or at right angles to the slope. See BMP , Topsoiling, and BMP , Surface Roughening for more information on seedbed preparation.

- Fertilization - As per suppliers and/or Soil Conservation Service recommendations. Developments adjacent to water bodies must use non-phosphorus fertilizer.

- Seeding - Seeding mixtures will vary depending on the exact location, soil type, slope, etc. Information on mixes and seeding depth may be obtained from local suppliers, the Montana State University Extension Service, or the Soil Conservation Service. However, approval to use any particular mix must be obtained from the local government.

- "Hydro-seeding" applications with approved seed-mulch-fertilizer mixtures may also be used.

- Re-seeding - Areas which fail to establish vegetative cover adequate to prevent erosion shall be re-seeded as soon as such areas are identified.

Maintenance

- Seeding should be supplied with adequate moisture. Supply water as needed, especially in abnormally hot or dry weather or on adverse sites. Water application rates should be controlled to prevent runoff.

- Re-Seeding - Areas which fail to establish vegetative cover adequate to prevent erosion shall be re-seeded as soon as such areas are identified.

Removal of temporary measures. All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil areas resulting from removal shall be permanently stabilized.

MULCHING AND MATTING

Symbol:

Definition:

Application of plant residues or other suitable materials to the soil surface.

Purpose:

To provide immediate protection to exposed soils during the period of short construction delays or over winter months through the application of plant residues, or other suitable materials, to exposed soil areas.

Mulches also enhance plant establishment by conserving moisture and moderating soil temperatures. Mulch helps hold fertilizer, seeds and topsoil in place in the presence of wind, rain, and runoff and maintains moisture near the soil surface.

This BMP may be used either alone or in conjunction with other BMPs such as temporary seeding.

Conditions Where Practice Applies

- In areas which have been seeded either for temporary or permanent cover, mulching should immediately follow seeding.
- Areas which cannot be seeded because of the season or are otherwise unfavorable for plant growth.
- Areas which have been seeded as specified in Temporary Seeding (BMP).
- In an area of greater than 2:1 slope, mulching should immediately follow seeding.

Advantages

1. Mulching offers instant protection to exposed areas.
2. Mulches conserve moisture and reduce the need for irrigation.

Disadvantages/Problems

1. Care must be taken to apply mulch at the specified thickness and on steep slopes mulch must be supplemented with netting.
2. Thick mulches can reduce the soil temperature, delaying seed germination.

Planning Considerations

Mulches are applied to the soil surface to conserve a desirable soil property or to promote plant growth. A surface mulch is one of the most effective means of controlling runoff and erosion on disturbed land.

Mulches can increase the infiltration rate of the soil, reduce soil moisture loss by evaporation, prevent

crusting and sealing of the soil surface, modify soil temperatures and provide a suitable microclimate for seed germination.

Organic mulch materials, such as straw, wood chips, bark, and wood fiber have been found to be most effective, although straw is preferred.

A variety of nets and mats have been developed for erosion control in recent years and these are also used as mulches, particularly in critical areas such as waterways. They may be used to hold other mulches to the soil surface.

The choice of materials for mulching will be based on the type of soil to be protected, site conditions, season and economics. It is especially important to mulch liberally in mid-summer and prior to winter and on cut slopes and southern slope exposures.

Organic Mulches

Straw - Straw is the mulch most commonly used in conjunction with seeding. Its use is recommended where immediate protection is desired and preferably where the need for protection will be less than 3 months. The straw should come from wheat or oats and may be spread by hand or machine. Straw can be windblown and must be anchored down. Common anchoring methods are:

1. Crimping, disking, rolling or punching into the soil;

2. Covering with netting;

3. Spraying with a chemical or fiber binder (tackifier); and

4. Keeping moist. Natural precipitation can often provide sufficient moisture.

Corn Stalks - These should be shredded into 4 to 6-inch lengths. Stalks decompose slowly and are resistant to windblow.

Wood Chips - Suitable for areas that will not be closely mowed and around ornamental plantings. Chips decompose slowly and do not require tacking. They must be treated with 12 pounds nitrogen per ton to prevent nutrient deficiency in plants. Chips can be a very inexpensive mulch if they are obtained from trees cleared on the site. However, both wood and bark chips tend to wash down slopes of more than 6 percent and create problems by clogging inlet grates, etc. and are therefore not preferred for use in those areas.

Bark Chips, Shredded Bark - By-products of timber processing. Used in landscaped plantings. Bark is also a suitable mulch for areas planted to grasses and not closely mowed; may be applied by hand or mechanically. Bark is not usually toxic to grasses or legumes and additional nitrogen fertilizer is not required.

Wood Fiber - Used in hydro-seeding operations, applied as part of the slurry. These short cellulose fibers do not require tacking although a tacking agent or soil binders are sometimes used with wood fiber. This form of mulch does not provide sufficient protection to erodible soils to be used alone during the severe heat of summer or for late fall seedings. Wood fiber hydro-seed slurries may be used to tack straw mulch. This combination treatment is well suited for steep slopes and critical areas and severe climate conditions.

There are other organic materials which make excellent mulches but are only available locally or seasonally. Creative use of these materials can reduce costs.

Chemical Mulches and Soil Binders - The use of synthetic, spray-on materials (except tacking agents used with hydro-seeding) is not recommended. A major problem with their use is the creation of impervious surfaces and, possibly, adverse effects on water quality. Contact the Water Quality Bureau prior to applying these materials.

Nets and Mats - Used alone, netting does not retain soil moisture or modify soil temperature. It stabilizes the soil surface while grasses are being established and is useful in grassed waterways and on slopes. Light netting may also be used to hold other mulches in place. Its relatively high cost makes it most suitable for small sites.

The most critical aspect of installing nets and mats is obtaining firm, continuous contact between the material and the soil. Without such contact, the material is useless and erosion occurs. It is important to use an adequate number of staples and to roll the material after laying it to ensure that the soil is protected.

Design Criteria

- Site Preparation = Same as Temporary Seeding.
- Mulch Materials, Application Rates and Specifications - See Table 1
- Erosion blankets (nets and mats) may be used on level areas, on slopes up to 50 percent and in waterways. Where soil is highly erodible, nets shall only be used in connection with an organic mulch such as straw and wood fiber. Jute nets shall be heavy, uniform cloth woven of single jute yarn, which if 36 to 48 inches wide shall weight an average of 1.2 pounds/linear yard. It must be so applied that it is in complete contact with the soil. If it is not, erosion will occur beneath it. Netting shall be securely anchored up to the soil with No. 11 gauge wire staples at least six inches long, with an overlap of three inches.
- Excelsior blankets are considered protective mulches and may be used alone on erodible soils and during all time of the year.
- See Figure 1 for orientation of netting and matting.

Maintenance

- Mulched areas should be checked periodically, especially following severe storms, when damaged areas of mulch or tie-down material should be repaired.

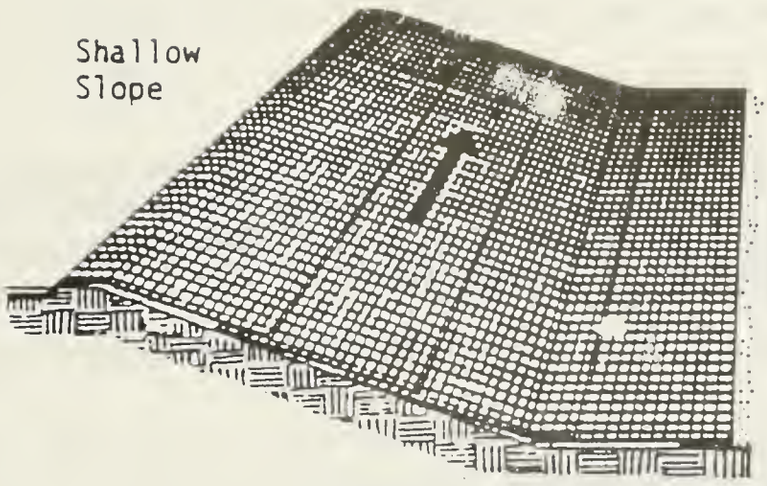
Removal of temporary measures. All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil areas resulting from removal shall be permanently stabilized.

TABLE 1 GUIDE TO MULCH MATERIALS, RATES AND USES

Mulch Material	Quality Standards	Application Rates		Depth of Application	Remarks[1]
		/1000 ft^2	/acre		
Gravel, slag or crushed stone	Washed, 1/4 - 1 1/2 size	9 yards^3		3 inches	Excellant mulch for short slopes and around woody plants and ornamentals. Use where subject to foot traffic. Approximately 2000 lbs/yard^3
Hay or straw	Air dried, free from unwanted seeds and coarse material	75-100 lbs. or 2-3 bales	1 1/2 - 2 1/2 tons or 90-120 bales	Minimum of 2 inches	Use where the mulching effect is to be maintained for >3 months. Is subject to wind blowing unless kept moist or tacked down. Most common and widely used mulching material. Can be used in critical erosion areas.
Wood fiber cellulose (partially digested wood fibers)	Dyed green should not contain growth inhibiting factors	25-30 lbs.	1000-1500 lbs.		If used on critical areas, double the normal application rate. Apply with hydromulchar. No tie-down required. Packaged in 100 lb. bags.

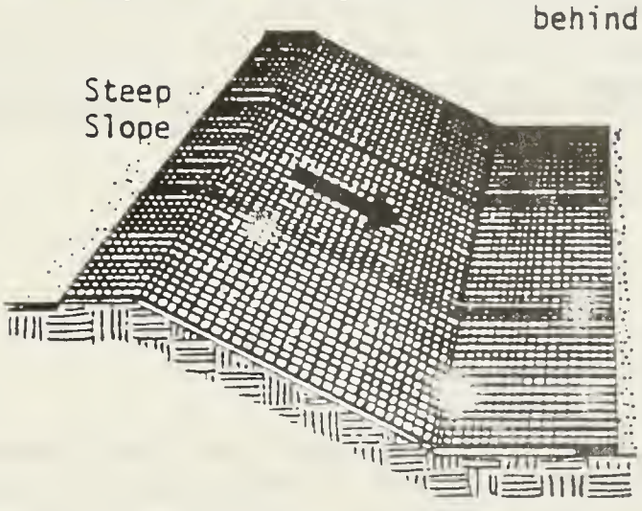
[1] All mulches will provide some degree of (1) erosion control, (2) moisture conservation, (3) weed control, and (4) reduction of soil crusting.

Figure 1 Orientation of Netting and Matting



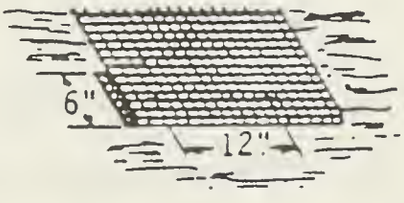
On shallow slopes, strips of netting may be applied across the slope.
(Slopes up to 1:1)

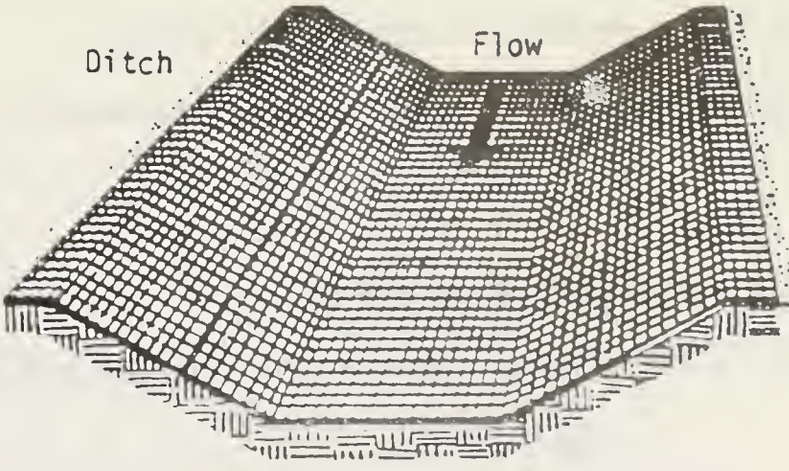
Where there is a berm at the top of the slope, bring the netting over the berm and anchor it behind the berm.



On steep slopes, apply strips of netting parallel to the direction of flow and anchor securely.
(Slopes greater than 1:1)

Bring netting down to a level area before terminating the installation. Turn the end under 6" and staple at 12" intervals.





In ditches, apply netting parallel to the direction of flow. Use check slots every 15 feet. Do not join strips in the center of the ditch.

CLEAR PLASTIC COVERING

Symbol:

Definition:

The covering with clear plastic sheeting of bare areas which need immediate protection from erosion.

Purpose:

To provide immediate temporary erosion protection to slopes and disturbed areas that cannot be covered by mulching, in particular during the specified seeding periods or as otherwise required by the local government. Also, to protect disturbed areas which must be covered during short periods of inactivity to meet November 1 - March 31 cover requirements.

This BMP may be used either alone or in conjunction with other BMPs such as temporary seeding.

Conditions Where Practice Applies

- Disturbed areas which require immediate erosion protection.
- Areas seeded during the time period from November 1 to March 1. (Note: Plantings at this time require clear plastic covering for germination and protection from heavy rains.

Advantages

1. Clear plastic covering is a good method of protecting bare areas which need immediate cover and for winter plantings.
2. May be quickly and easily placed.

Disadvantages/Problems

1. There can be problems with vandals and maintenance.
2. The sheeting will result in rapid, 100% runoff which may cause serious erosion problems and/or flooding at the base of slopes unless the runoff is properly intercepted and safely conveyed by a collecting drain. This is strictly a temporary measure, so permanent stabilization is still required.
3. It is relatively expensive.
4. The plastic may blow away if it is not adequately overlapped and anchored.
5. Ultraviolet and possibly visible light can cause some types of plastic to become brittle and easily torn.

Design Criteria

- Clear plastic sheeting shall have a minimum thickness of 6 mil.
- Covering shall be installed and maintained tightly in place by using sandbags or tires on ropes

with a maximum 10 foot grid spacing in all directions. All seams shall be taped or weighted down full length and there shall be at least a 1 to 2 foot overlap of all seams. Seams should then be rolled and staked or tied.

- Covering shall be installed immediately on areas seeded between November 1 to March 1 and remain until vegetation is firmly established.

- When the covering is used on unseeded slopes, it shall be left in place until the next seeding period.

- Sheeting should be toed in at the top of the slope to prevent surface flow beneath the plastic.

- Sheeting should be removed as soon as is possible once vegetation is well grown to prevent burning the vegetation through the plastic sheeting, which acts as a greenhouse.

Maintenance

- Check regularly for rips and places where the plastic may be dislodged. Contact between the plastic and the ground should always be maintained. Any air bubbles found should be removed immediately or the plastic may rip during the next windy period. Re-anchor or replace the plastic as necessary.

Removal of temporary measures. All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil areas resulting from removal shall be permanently stabilized.

PRESERVING NATURAL VEGETATION

Symbol:

Definition:

Minimizing exposed soils and resulting increased erosion by clearing only where construction occur.

Purpose:

To reduce erosion by preserving natural vegetation wherever practicable.

This BMP may be used alone or in conjunction with other BMPs such as Clear Plastic Covering.

Conditions Where Practice Applies

- Natural vegetation should be preserved on steep slopes, near perennial and intermittent watercourses or swales and on building sites in wooded areas.
- As required by local governments.

Advantages

Preserving natural vegetation will:

1. Help reduce soil erosion.
2. Beautify an area.
3. Save money on landscaping costs.
4. Provide areas for wildlife.
5. Possibly increase the value of the land.
6. Provide buffers and screens against noise.
7. Moderate temperature changes and provide shade and cover habitat for surface waters and land. This is especially important where detention ponds drain to salmonid-bearing streams. Increases in water temperature tend to lower the dissolved oxygen available for aquatic life.

Disadvantages/Problems

1. Save individual trees can be difficult and older trees may become a safety hazard. Cottonwood and alder trees are especially prone to blowdown.

Planning Considerations

New development often takes place on tracts of forested land. In fact, building sites are often selected

because of the presence of mature trees. However, unless sufficient care is taken and planning done, in the interval between buying the property and completing construction much of this resource is likely to be destroyed. The property owner is ultimately responsible for protecting as many trees as possible, with their understory and groundcover. This responsibility is usually exercised by agents--the planners, designers and contractors. It takes 20 to 30 years for newly planted trees to provide the benefits for which we value trees so highly.

Design Criteria

Natural vegetation can be preserved in natural clumps or as individual trees, shrubs and vines.

The preservation of individual plants is more difficult because equipment is generally used to remove unwanted vegetation. The points to remember when attempting to save individual plants are:

- Is the plant worth saving? Consider the location, species, size, age, vigor and the work involved. Local governments may also have ordinances to save natural vegetation and trees.

- Is the tree or shrub a desirable plant? Is it shallow-rooted, do the roots seek water or are insects and disease a problem? Shallow-rooted plants can cause problems in the establishment of lawns or ornamental plants. Water-seek roots can block sewer and tile lines. Insects and diseases can make the plant undesirable. This is especially true with aphid on alder and maple.

- Old and/or large plants do not generally adapt to changes in environment as readily as young plants of the same species. Usually, it is best to leave trees which are less than 40 years of age. Some of the hardwoods (red alder, cherry, etc) mature at approximately 50 years of age. After maturity they rapidly decline in vigor. Conifers, after 40 years of age, may become a safety hazard due to the possibility of breakage or blowdown, especially where construction has left only a few scattered trees in an area that was formerly dense woods. While old large trees are sometime desirable, the problem of later removal should be considered. However, again local governments may have requirements to preserve older, larger specimen trees. It is expensive to cut a large tree and to remove the tree and stump from a developed area. Thinning some branches from trees can provide avenues for wind and hence lessen the "sail" effect.

- Clearly flag or mark areas around trees that are to be saved. It is preferable to keep ground disturbance away from the trees at least as far out as the dripline.

Plants need protection from three kinds of injuries:

- Construction Equipment -- This injury can be above or below the ground level. Damage results from scarring, cutting of roots and compaction of the soil. Such injuries can be prevented by roping or fencing a buffer zone around plants to be saved prior to construction (Figure 2).

- Grade Changes -- Changing the natural ground level will alter grades which affect the plant's ability to obtain the necessary air, water and minerals. Minor fills usually do not cause problems although sensitivity between species does vary. Cedars are more sensitive. Trees can tolerate fill of 6 inches or less. For shrubs and other plants the fill should be less. When there are major changes in grade it may become necessary to supply air to the roots of plants. This can be done by placing a layer of gravel and a tile system over the roots before the fill is made. A tile system protects a tree from a raised grade.

  The tile system should be laid out on the original grade leading from a dry well around the tree trunk and the system is covered with small stones to allow air to circulate over the root area (see

Figure 2).

Lowering the natural ground level can seriously damage trees and shrubs. The highest percentage of the plant roots are in the upper 12 inches of the soil and cuts of only 2-3 inches can cause serious injury. To protect roots is may be necessary to terrace the immediate area around the plants to be saved. If roots are exposed, construction of retaining walls may be needed to keep the soil in place. Plants can also be preserved by leaving them on an undisturbed, gently sloping mound. To increase the chances for survival, it is best to limit grade changes and other soil disturbances to areas outside the dripline of the plant (Figure 2).

- Excavations -- Protect trees and other plants when excavating for tile, water and sewer lines. Where possible, the trenches should be routed around trees and large shrubs. When this is not possible, it is best to tunnel under them. This can be done with hand tools or with power augers.

  If it is not possible to route the trench around plants to be saved, then the following should be observed:

  Cut as few roots as possible. When you have to cut -- cut clean. Paint cut root ends with a wood dressing like asphalt base paint.

  Backfill the trench as soon as possible.

  Tunnel beneath root systems as close to the center of the main trunk to preserve most of the important feeder roots.

  Some problems that can be encountered with a few specific trees are:

  - Maple, dogwood, red alder, western hemlock, western red cedar and Douglas fir do not readily adjust to changes in environment and special care should be taken to protect these trees.

  - The tipover hazard of Pacific silver fir is high while that of western hemlock is moderate. The danger of tipover increases where dense stands have been thinned. Other species (unless they are on shallow, wet soils under 20 inches deep) have a low tipover hazard.

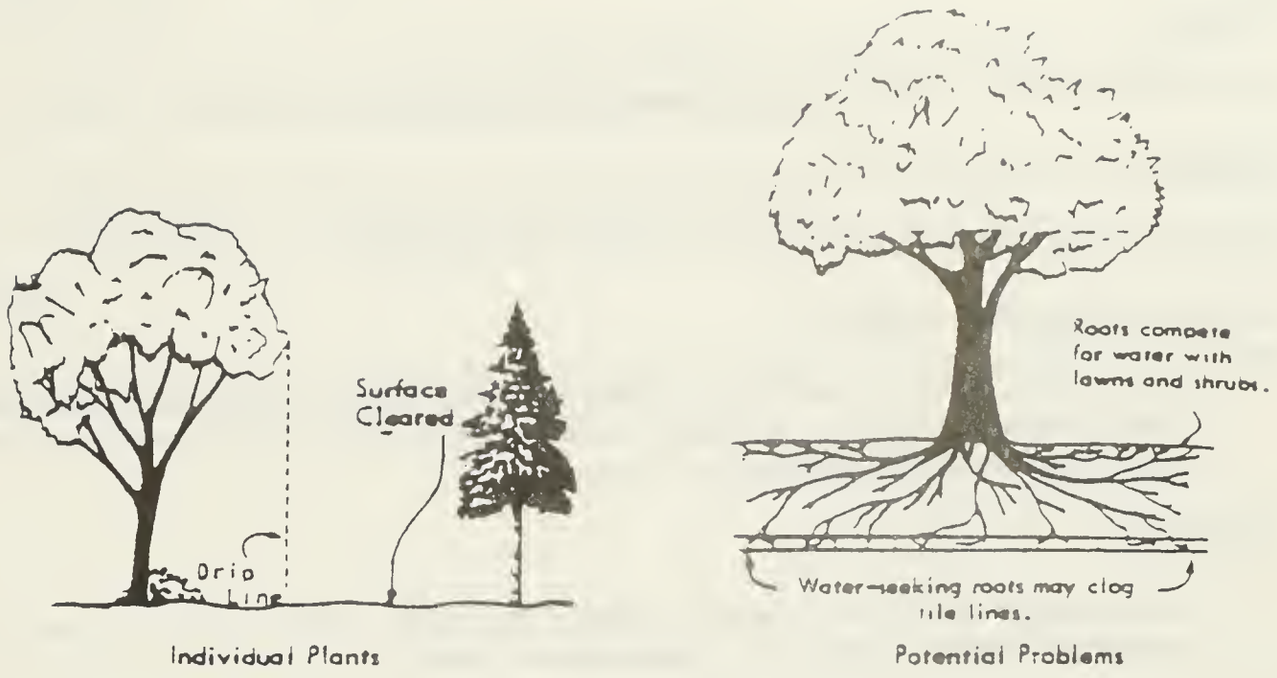
  - Cottonwoods, maples and willows have water-seeking roots. These can cause trouble in sewer lines and filter fields. On the other hand, they thrive in high moisture conditions that other trees would succumb to.

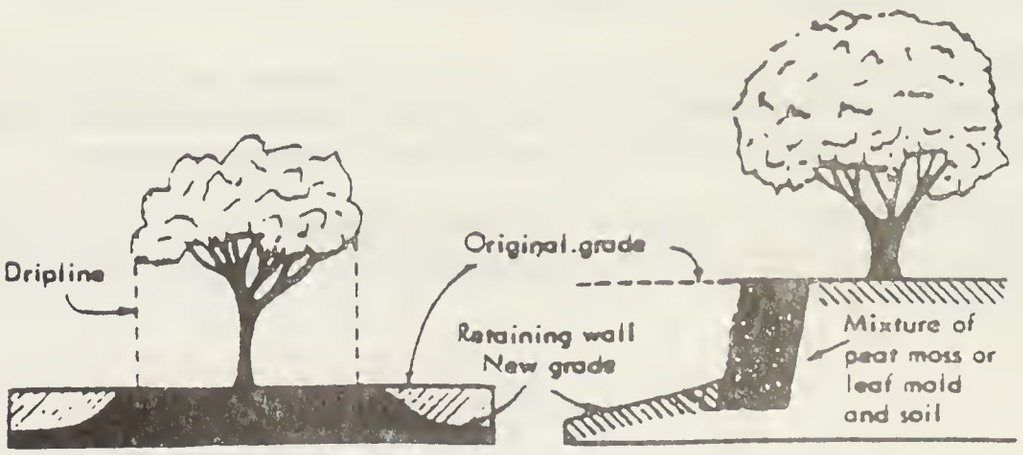
  - Thinning operations in pure or mixed stands of grand fir, Pacific silver fir, noble fir, Sitka spruce, western red cedar, western hemlock, Pacific dogwood and red alder can cause serious disease problems. Disease can become established through damaged limbs, trunks, roots and freshly cut stumps. Diseased and weakened trees are also susceptible to insect attack.

Maintenance

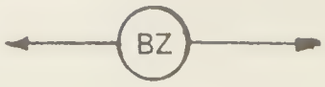
- Inspect flagged areas regularly to make sure flagging has not been removed. If tree roots have been exposed or injured, recover and/or seal them.

Figure 2 Preserving Natural Vegetation





BUFFER ZONES

Symbol: 

Definition:

An undisturbed area or strip of natural vegetation or an established planting.

Purpose:

Provides a living filter to reduce soil erosion and runoff velocities.

Conditions Where Practice Applies

- Natural buffer zones are used along streams and other bodies of water that need protection from erosion and sedimentation. Vegetative buffer zones can be used to protect natural swales and incorporated into natural landscaping of an area.

Advantages

1. Buffer zones provide critical habitat adjacent to streams and wetlands, as well as assist in controlling erosion, especially on unstable steep slopes.

2. Act as a visibility and noise screen

Disadvantages/Problems

1. Extensive buffers will increase development costs.

Design Criteria

- Preserving natural vegetation or plantings in clumps, blocks or stripes is generally the easiest and most successful method.

- Leave all unstable steep slopes in natural vegetation.

- Fence or flag clearing limits and keep all equipment and construction debris out of the natural areas.

- Keep all excavations outside the dripline of trees and shrubs.

- **Do not push debris or extra soil into the buffer zone** area because it will cause damage from burying and smothering of existing vegetation.

- Vegetative buffer zones for streams, lakes or other waterways should be a minimum of 50 feet wide on each side with increase subject to other on-site sensitive conditions, existing vegetative conditions and erosion hazard potential (see below for setback guidelines).

MINIMUM RECOMMENDED GUIDELINES FOR UNDISTURBED VEGETATIVE SETBACKS FROM STREAMS, LAKES AND OTHER NATURAL DRAINAGEWAYS: (Expressed in feet from the "ordinary high water mark")

1. The width of the buffer zone is measured perpendicular to the stream, lake, wetland, etc. from the ordinary high water mark to a point 50 feet from the ordinary high water mark.

2. The buffer zone width is 50 feet distant on each side of streams, lakes, wetlands, or other bodies of water.

3. Where the slope of the buffer zone is greater than 35%, the buffer zone width is 100 feet on each side of streams, lakes, wetlands or other water bodies.

4. If an established road exists between 50-100 feet from the ordinary high water mark, the buffer zone boundary is located at the toe of the road fill.

Maintenance:

Inspect the area frequently to make sure that flagging remains in place and the area remains undisturbed.

Permanent Seeding and Planting

Symbol:

Definition:

The establishment of perennial vegetative cover on disturbed areas.

Purpose:

To establish permanent vegetation (such as grasses, legumes, trees and shrubs) as rapidly as possible to prevent soil erosion by wind or water, and to improve wildlife habitat and site esthetics.

To provide pollutant filtration (biofiltration) in vegetation-lined channels and to establish constructed wetlands as required.

This BMP may be used alone or in conjunction with other BMPs such as Clear Plastic Covering.

Conditions Where Practice Applies

- Areas which will not be brought to final grade for a year or more.
- In vegetation-lined channels.
- In retention or detention ponds as required.

Advantages

* Well established grass and ground cover can give an aesthetically pleasing, finished look to a development.

Disadvantages/Problems

1. Vegetation and mulch cannot prevent soil slippage and erosion if soil is not inherently stable.
2. Coarse, high grasses that are not mowed can create a fire hazard in some locales. Mowed grass, however, provides less stability and sediment filtering capacity.
3. Grass planted to the edge of a watercourse may encourage fertilizing and mowing near the waters edge and increase nutrient and pesticide contamination.
4. May require regular irrigation to establish and maintain.

Planning Considerations

Vegetation controls erosion by reducing the velocity and the volume of overland flow and protecting the bare soil surface from raindrop impact.

Areas which must be stabilized after the land have been disturbed require vegetative cover. The most common and economical means of establishing this cover is by seeding grasses and legumes.

Advantages of seeding over other means of establishing plants include the small initial establishment

cost, the wide variety of grasses and legumes available, low labor requirement and eat of establishment in difficult areas.

Disadvantages which must be dealt with are the potential for erosion during the establishment stage, a need to reseed areas that fail to establish, limited periods during the year suitable for seeding and a need for water and appropriate climatic conditions during germination.

There are so many variables in plant growth that an end product cannot be guaranteed. Much can be done in the planning stages to increase the chances for successful seeding. Selection of the right plant materials for the site, good seedbed preparation, timing and conscientious maintenance are important. Whenever possible, native species of plants should be used for landscaping. These plants are already adapted to the locale and survivability should be higher than with exotic species.

native species are also less likely to require irrigation, which can be a large maintenance burden and is not cost-effective or ecologically sound.

If non-native plant species are used, they should be tolerant of a large range of growing conditions and as low-maintenance as possible.

Design Criteria

- Vegetation cannot be expected to supply an erosion control cover and prevent slippage on a soil that is not stable due to its texture, structure, water movement or excessive slope.

- Seeding should be done immediately after final shaping, except during the period of November 1 through March 1, when the site should be protected by mulching or plastic covering until the next seeding period.

- Permanent vegetation may be in the form of grass-type growth by seeding or sodding, or it may be trees or shrubs, or a combination of these. Establishing this cover may require the use of supplemental materials, such as mulch or jute netting.

- Site Preparation: Install needed surface runoff control measures such as gradient terraces, berms, dikes, level spreaders, waterways and sediment basins prior to seeding or planting.

- Seeding Grasses and Legumes: Seedbed Preparation -- If infertile or coarse textured subsoil will be exposed during land shaping, it is best to stockpile topsoil and respread it over the finished slope at a 2 to 6 inch depth and roll it to provide a firm seedbed. If construction fills have left soil exposed with a loose, rough, or irregular surface, smooth with blade and roll. If cuts or construction equipment have left a tightly compacted surface, break with chisel plow or other suitable implement. Perform all cultural operations across or at right angles to the slope (contoured), such as with cat tracks on the final pass. The seedbed should be firm with a fairly fine surface.

- Soil Amendments: Rates will depend on site characteristics and soil, but as a guide, apply lime at the rate of 100 pounds per 1,000 square feet. Apply actual nitrogen at the rate of 1-2 pounds per 1,000 square feet, phosphoric acid at the rate of 1.5 pounds per 1,000 square feet and potassium at the rate of 1.5 pounds per 1,000 square feet. Work in lime and other nutrients to a depth of a minimum of 5 inches with suitable equipment. Scatter amendments uniformly and work into the soil during seedbed preparation.

Seeding - Apply an appropriate mixture to the prepared seedbed. Contact the local Soil

Conservation Service for seed mixture and rates.

Cover the seed with topsoil or mulch no deeper than 1/2 inch.

"Hydro-seeding" applications with approved seed-mulch-fertilizer mixtures may also be used.

Wetlands Seed Mixtures - For newly created wetlands, a biologist should design plantings to provide the best chance of success. Consult with the local Montana Department of Fish, Wildlife and Parks for information concerning seeding mixtures for wetlands. See Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs for more information on constructed wetlands. Do not under any circumstances use introduced, invasive plants like reed canarygrass (Phalaris arundinacea) or purple loosestrife (Lythrum salicaria). Using plants such as these will cause many more problems than they will ever solve.

Tree and Shrub Planting

Besides their erosion and sediment control values, trees and shrubs also provide natural beauty and wildlife benefits. When used for the latter, they are usually more effective when planted in clumps or blocks. These procedures should be followed:

1. Trees and shrubs will do best in topsoil. If no topsoil is available, they can be established in subsoil with proper amendment. If trees and shrubs are to be planted in subsoil, particular attention should be paid to amending the soil with generous amounts of organic matter. Mulches should also be used.

2. Good quality planting stock should be used. Normally one or two-year old deciduous seedlings and three or four-year old coniferous transplants, when properly produced and handled, are adequate. Stock should be kept cool and moist from time of receipt and planted as soon as possible.

3. Competing vegetation, if significant, should be pulled out of the area where the plant or plants are to be placed.

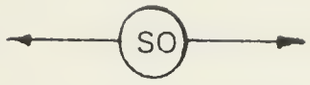
Maintenance

Inspect seeded areas for failure and make necessary repairs and reseed immediately. Conduct or follow-up survey after one year and replace failed plants where necessary.

- If vegetative cover is inadequate to prevent rill erosion, overseed and fertilize in accordance with soil test results.

- If a stand has less than 40% cover, reevaluate choice of plant materials and quantities of lime and fertilizer. Re-establish the stand following seedbed preparation and seeding recommendations, omitting lime and fertilizer in the absence of soil test results. If the season prevents resowing, mulch or erosion netting is an effective temporary cover.

SODDING

Symbol: 

Definition:

Stabilizing fine-graded disturbed areas by establishing permanent grass stands with sod.

Purpose:

To establish permanent turf for immediate erosion protection or to stabilize drainageways where concentrated overland flow will occur.

Conditions Where Practice Applies

- Disturbed areas which require immediate vegetative cover.
- Waterways carrying intermittent flow, where immediate stabilization or aesthetics are factors and other locations which are particularly suited to stabilization with sod.

Advantages

1. Sod will give immediate protection.
2. Sod gives an immediate vegetative cover which is both effective in checking erosion and is aesthetically pleasing.
3. Good sod has a high density of growth which is superior in protection to a recently seeded area.
4. Sod can be place at any time of the year provided that soil moisture is adequate and the ground is not frozen.

Disadvantages/Problems

1. Sod is expensive.
2. Sod is heavy and handling costs are high.
3. Good quality sod, free from weed species, may be difficult to obtain.
4. If laid in an unfavorable season, midsummer irrigation may be required. This also applies to very droughty sand soils.
5. Grass species in the sod may not be suitable for site conditions.
6. If mowing is required, do not use grass sod on slopes steeper than 3:1 (use minimum maintenance ground covers).
7. If not anchored or drained properly, sod will "roll up" in grassed waterways.

Design Criteria

- Shape and smooth the surface to final grade in accordance with the approved grading plan.
- Use of topsoil shall be in accordance with the requirements of Topsoiling.
- Add lime or acid to reach a soil pH value of 7.0 (based on soil tests).
- Fertilize according to a soil test or in the absence of a test use available nitrogen, phosphorus and potash as prescribed for permanent seeding. Use fertilizers that are not highly soluble.
- Work lime and fertilizer into the soil 1 to 2 inches deep and smooth the surface.
- Lay strips of sod beginning at the lowest area to be sodded and perpendicular to the direction of water flow. Wedge strips securely in place. Square the ends of each strip to provide for a close, tight fit. Stagger joints at least 12 inches. Staple if on steep slopes.
- Roll the sodded area and irrigate.
- When sodding is carried out in alternating strips, or other patterns, seed the areas between the sod immediately after sodding.
- Sods should be free of weeds and be of uniform thickness (approximately 1 inch) and should have a dense root mat for mechanical strength.

Maintenance

- Inspect sodded areas regularly, especially after large storm events. Re-tack, re-sod or reseed as necessary.

TOPSOILING

Symbol:

While not a permanent cover practice in itself, topsoiling has been included in this section because it is an integral component of preparing permanent cover to those areas where there is an unsuitable soil surface for plant growth. Use of in-situ or imported topsoil is always preferable to planting in subsoil.

Definition:

Preserving and using topsoil to enhance final site stabilization with vegetation.

Purpose:

To provide a suitable growth medium for final site stabilization with vegetation.

This BMP may be used alone or in conjunction with other BMPs such as Clear Plastic Covering.

Conditions Where Practice Applies

- Preservation or importation of topsoil is determined to be the most effective method of providing a suitable growth medium and the slopes are less than 2:1.

- Applicable to those areas with highly dense or impermeable soils or areas where planting is to be done in subsoil, where mulch and fertilizer alone would not provide a suitable growth medium.

Advantages

1. Topsoil stockpiling ensures that a good growth medium will be available for establishing pl;ant cover on graded areas. It has a high organic matter content and friable consistency, water holding capacity and nutrient content.

2. The stockpiles can be used as sound and view baffles during construction.

Disadvantages/Problems

1. Stripping, stockpiling and reapplying topsoil or importing topsoil may not always be cost-effective. It may also create an erosion problem if improperly secured.

2. Unless carefully located, storage banks of topsoil may also obstruct site operations and therefore require double handling.

3. Topsoiling can delay seeding or sodding operations, increasing exposure time of denuded areas.

4. Most topsoil contains some weed seeds.

Planning Considerations

Topsoil is the surface layer of the soil profile, generally characterized as being darker than the subsoil due to the presence of organic matter. It is the major zone of root development, carrying much of the nutrients available to plants and supplying a large share of the water used by plants.

Topsoiling is strongly recommended where ornamental plants or high-maintenance turf will be grown. Topsoiling is a required procedure when establishing vegetation on shallow soils and soils of critically low pH (high acid) levels.

If topsoiling is to be done, the following items should be considered:

1. *Whether an adequate volume of topsoil exists on the site. Topsoil should be spread at a compacted depth of 2-4 inches. More topsoil will be needed if the subsoil is rocky.*

2. *Location of the topsoil stockpile so that it meets specifications and does not interfere with work on the site.*

3. *Allow sufficient time in scheduling for topsoil to be spread and bonded prior to seeding, sodding or planting.*

4. *Care must be taken not to apply to subsoil if the two soils have contrasting textures. Sandy topsoil over clayey subsoil is a particularly poor combination, as water creeps along the junction between the soil layers and causes the topsoil to slough.*

5. *If topsoil and subsoil are not properly bonded, water will not infiltrate the soil profile evenly and it will be difficult to establish vegetation.*

Design Criteria

- Field exploration of the site shall be made to determine if there is surface soil of sufficient quantity and quality to justify stripping. Topsoil shall be friable and loamy (loam, sandy loam, silt loam, sandy clay loam, clay loam). Areas of natural ground water recharge should be avoided.

- Stripping shall be confined to the immediate construction area. A 4 to 6 inch stripping depth is common, but depth may vary depending on the particular soil. All surface runoff control structures shall be in place prior to stripping.

- Stockpiling of topsoil shall occur in the following manner:

  a. Side slopes of the stockpile shall not exceed 2:1.

  b. An interceptor dike with gravel outlet and silt fence shall surround all topsoil stockpiles.

  c. Erosion control seeding or covering with clear plastic of stockpiles shall be completed within 15 days of the formation of the stockpile.

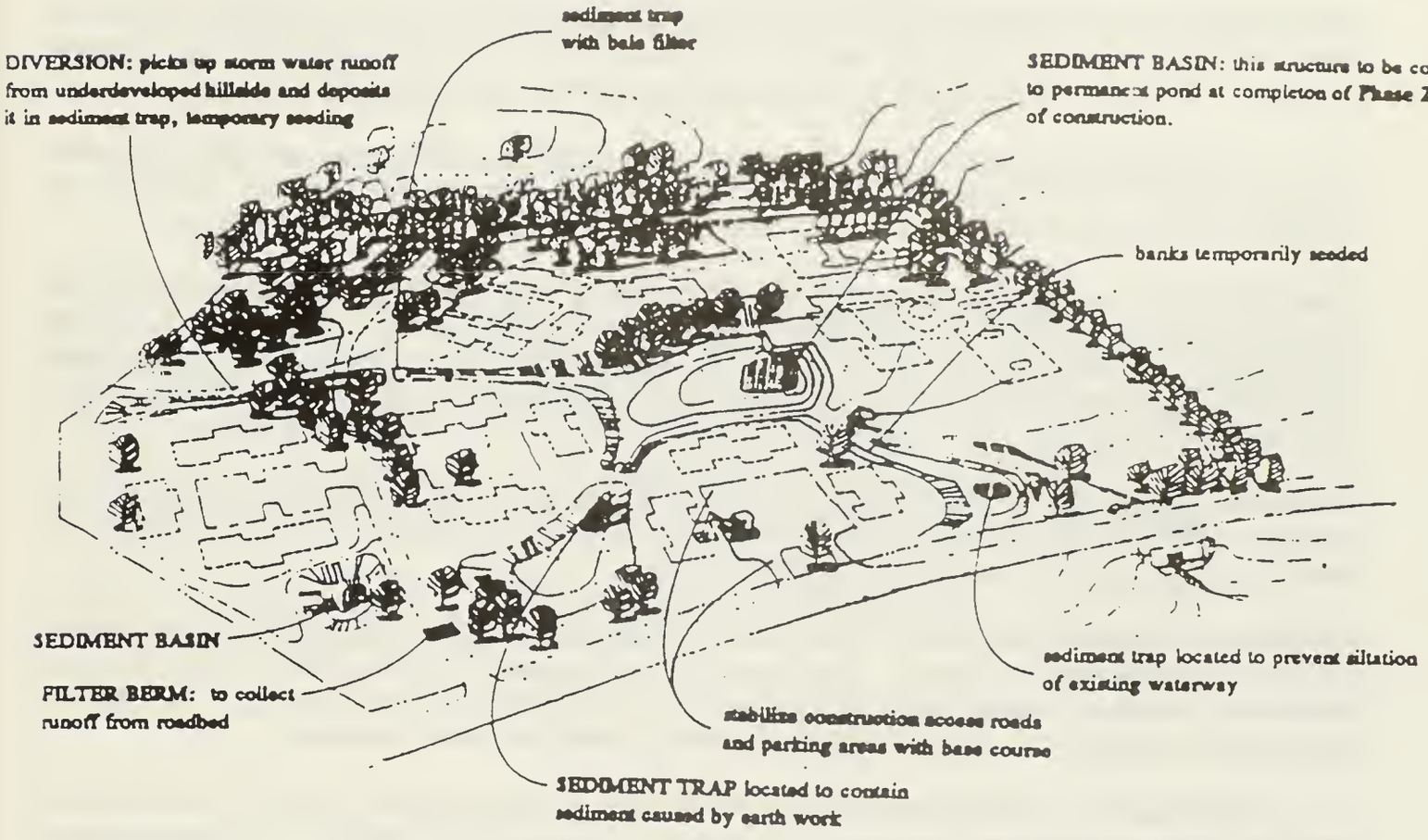
- Topsoil shall not be placed while in a frozen or muddy condition, when the subgrade is excessively wet or when conditions exist that may otherwise be detrimental to proper grading or proposed sodding or seeding.

- Previously establish grades on the areas to be topsoiled shall be maintained according to the approve plan.

Maintenance

- Cover piles with clear plastic covering until needed.

Temporary Control Measures are Used During Construction


sediment trap
with bale filter
DIVERSION: picks up storm water runoff
from underdeveloped hillside and deposits
it in sediment trap, temporary seeding
SEDIMENT BASIN: this structure to be converte
to permanent pond at completon of Phase 2
of construction.
banks temporarily seeded
SEDIMENT BASIN
FILTER BERM: to collect
runoff from roadbed
sediment trap located to prevent siltation
of existing waterway
stabilize construction access roads
and parking areas with base course
SEDIMENT TRAP located to contain
sediment caused by earth work

STANDARDS AND SPECIFICATIONS FOR STRUCTURAL AND BIOMECHANICAL PRACTICES

Structural and biomechanical control practices are used to either reduce erosion or retain sediment on the construction site. The BMPs in this section have been divided into two basic groups based on these characteristics. The standards and specifications of each BMP are presented in the same format used for nonstructural practices.

Structural erosion control BMPs include measures for site stabilization (such as stabilized construction entrances), slope protection (such as pipe slope drainings) and drainageway protection (such as level spreaders). Sediment control BMPs include filter fences, berms and sediment traps.

Structural control is more effective when combined with vegetative protection and appropriate grading practices as part of an Erosion Control Plan (ECP). Control measure may be either permanent or temporary depending on whether they will remain in use after development is complete.

Although temporary structures are emphasized in this section, they may be combined with permanent control facilities to provide protection of downstream properties during construction. Temporary BMPs provide siltation control, but downstream flooding and erosion protection must also be provided. Accordingly, the allowable discharge from development sites with drainage areas of three or more acres shall not exceed the pre-development peak flow for the 2, 10, and 100-year storms.

It is also important not to disturb areas of natural ground water discharge and/or retention. To accomplish this, a permanent detention pond may have to be constructed first with modifications allowing it to temporarily function as a sediment pond.

The design of structural measures for erosion and sedimentation control is accomplished by carefully predetermining appropriate factors. The design, storm, maximum drainage area, slope and other restrictions are noted for each BMP. The design criteria and limitations are important; if they are not observed, the simplest measures will fail and erosion control will not be achieved.

In most ECP designs, especially for sites larger than 5 acres, several small structures will function more effectively than a single large structure. For example, a combination of BMPs, such as filter fences, temporary dikes/swales and several small sediment traps/ponds (depending on subbasin configuration) may be used as opposed to a single large sediment pond.

Maintenance is also of critical importance for proper operation of structural BMPs ad must be considered in their design. Maintenance requirements and frequency vary with each BMP and its performance criteria. At a minimum, the ECP shall require monthly maintenance or following each runoff producing storm (whichever occurs more frequently), for silt removal and proper operation of all BMPs. BMPs may have to be replaced or relocated depending on their performance under field conditions.

The following factors should be considered when designing structural control measures:

- Use material available on-site whenever possible.
- Keep structures simple and take advantage of permanent facilities unless the permanent structures are for infiltration.
- Install the most important control structures first.

- Install BMPs correctly; visit the site during and after storms to be sure that all structures are properly located, constructed and functioning as designed.

- Install control measures in sequences which minimize land disturbance. For example, install interceptor dikes/swales and drainage trenches before seeding to avoid disturbing the seedbed. Avoid disturbing or removing existing vegetation whenever possible.

- Do not block a natural drainageway. Make certain that all necessary permits have been obtained before starting any work in a wetland, stream or other sensitive area. *

- Place control measures out of the way of construction operations.

- Make field modifications where necessary with the approval of the local jurisdiction.

- Provide access for maintenance.

Although design and construction standards and specifications are presented in some detail, this section is not a substitute for training in hydraulic and construction engineering. The materials presented are guidelines to assist in the design of erosion control measures. The standards and specifications provided should not be considered rigid requirements except where statutory requirements are indicated. Where local experience has shown that an alternate design will work better, it may be used as long as it is approved the Water Quality Bureau. Designers are encouraged to continuously seek out new, more reliable solutions for controlling erosion and sediment.

*A Guide to Stream Permitting in Montana discusses all permits required. You may obtain a copy of this guide by contacting the Montana Association of Conservation Districts, 501 N. Sanders, Helena.

STABILIZED CONSTRUCTION ENTRANCE AND TIRE WASH

Symbol:

Definition:

A temporary stone stabilized pad located at points of vehicular entrance and exits on a construction site.

Purpose:

Construction access routes. Wherever construction vehicle access routes intersect paved roads provisions must be made to minimize the transport of sediment (mud) onto the paved road. If sediment is transported onto a road surface, the roads shall be cleaned thoroughly at the end of each day. Sediment shall be removed from roads by shoveling or sweeping and be transported to a controlled sediment disposal area. Street washing shall be allowed only after sediment is removed in this manner.

To reduce the amount of mud, dirt, rocks, etc. transported onto public roads by motor vehicles or runoff by constructing a stabilized pad of rock spalls at entrances to construction sites and washing of tires during exit.

Conditions Where Practice Applies

- Whenever traffic will be leaving a construction site and moving directly onto a public road or other paved areas.

Advantages

1. Mud on vehicle tires is significantly reduced which avoids hazards caused by depositing mud on the public roadway.

2. Sediment, which is otherwise contained on the construction site, does not enter stormwater runoff elsewhere.

Planning Considerations

Construction entrances provide an area where mud can be removed from vehicle tires before they enter a public road. If the action of the vehicle traveling over the gravel pad is not sufficient to remove the majority of the mud,then the tires must be washed before the vehicle enters a public road. If washing is used, provisions must be made to intercept the wash water and trap the sediment before it is carried off-site. Construction entrances should be used in conjunction with the stabilization of construction roads to reduce the amount of mud picked up by vehicles.

It is important to note that this BMP will only be effective if sediment control is used throughout the rest of the construction site.

Design Criteria

- Material should be quarry spalls, 4 inches to 8 inches in size.

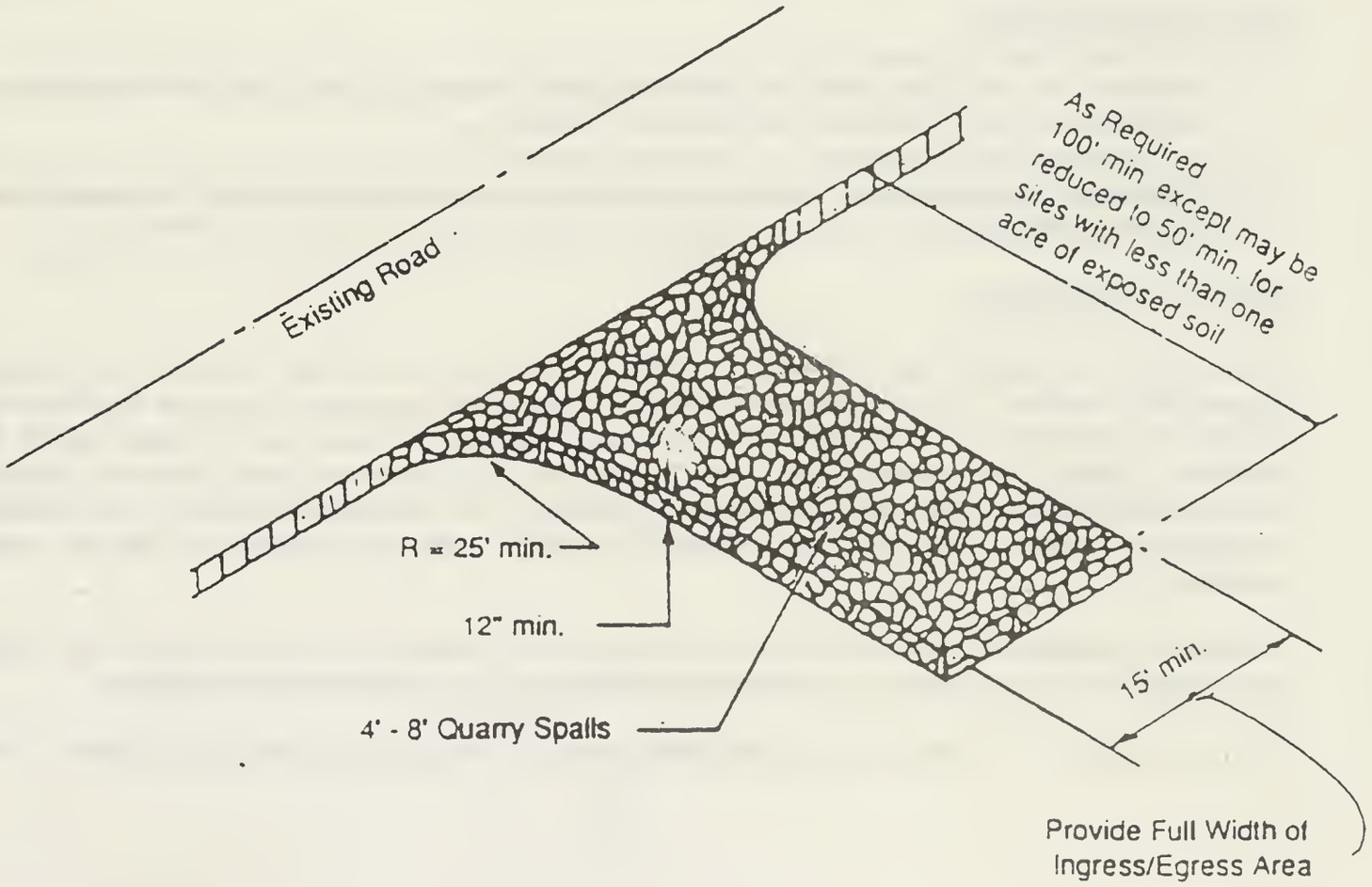
and may be reduced to 50 feet in length for sites less than 1 acre.

- A filter fabric fence should be installed down-gradient from the construction entrance in order to contain any sediment-laden runoff from the entrance.
- Width shall be the full width of the vehicle ingress and egress area (minimum 20 feet).
- Additional rock should be added periodically to maintain proper function of the pad.
- Tire washing should be done before the vehicle enters a paved street. Washing should be done on an area covered with crushed rock and the wash water should be drained to a sediment retention facility such as a sediment trap or basin.

Maintenance

- The entrance shall be maintained in a condition which will prevent tacking or flow of mud onto public rights-of-way. This may require periodic top dressing with 2-inch stone, as conditions demand,and repair and/or clean out of any structures used to trap sediment. All materials spilled, dropped, washed or tracked from vehicles onto roadways or into storm drains must be removed immediately.

Removal of temporary measures. All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil areas resulting from removal shall be permanently stabilized.



CONSTRUCTION ROAD STABILIZATION

Symbol:

Definition:

The temporary stabilization of access roads, subdivision roads parking areas and other on-site vehicle transportation routes with stone immediately after grading.

Purpose:

1. To reduce erosion of temporary road beds by construction traffic during wet weather.

2. To reduce the erosion and therefore regrading of permanent road beds between the time of initial grading and final stabilization.

Conditions Where Practice Applies

- Wherever rock-base roads or parking areas are constructed, whether permanent or temporary, for use by construction traffic.

- Note: Exceptions may be granted in areas with gravelly type soils, such as the Everett series, as approved by the local government.

Advantages

1. Efficient construction road stabilization not only reduces on-site erosion but can significantly speed on-site work, avoid instances of immobilized machinery and delivery vehicles and generally improve site efficiency and working conditions during adverse weather.

Disadvantages/Problems

1. Measures on temporary roads must be cheap not only to install but also to demolish if they interfere with the eventual surface treatment of the area.

2. Application of aggregate to construction roads may need to be made more than once during a construction period.

Planning Considerations

Areas which are graded for construction vehicle transport and parking purposes are especially susceptible to erosion. The exposed soil surface is continually disturbed, leaving no opportunity for vegetative stabilization. Such areas also tend to collect and transport runoff waters along their surfaces. During wet weather, they often become muddy quagmires which generate significant quantities of sediment that may pollute nearby streams or be transported off-site on the wheels of construction vehicles. Dirt roads can become so unstable during wet weather that they are virtually unusable.

Immediate stabilization of such areas with stone may cost money at the outset, but it may actually save money in the long run by increasing the usefulness of the road during wet weather.

Permanent roads and parking areas should be paved as soon as possible after grading. As an

alternative, the early application of stone may solve potential erosion and stability problems and eliminate later regrading costs. Some of the stone will also probably remain in place for use as part of the final base course of the road.

Design Criteria

- A 6-inch course of 2 to 4-inch crushed rock, gravel base or crushed surfacing base course shall be applied immediately after grading or the completion of utility installation within the right-of-way. A 4-inch course of asphalt treated base (ATB) may be used in lieu of the crushed rock or as advised by the local government.

- Where feasible, alternative routes should be made for construction traffic; one for use in dry conditions, the other for wet conditions which incorporate the measures listed below.

- Temporary roads should follow the contour of the natural terrain to the maximum extent possible. Slope should not exceed 15 percent. Roadways should be carefully graded to drain transversely. Provide drainage swales on each side of the roadway in the case of a crowned section or one side in the case of super-elevated section. Drainage swales shall be designed in accordance with the standards given in this section.

- Installed inlets shall be protected to prevent sediment-laden water entering the drain sewer system (see Storm Drain Inlet Protection).

- Simple gravel berms without a trench can be used for less traveled roads.

- Undisturbed buffer areas should be maintained at all stream crossings.

- Areas adjacent to culvert crossings and steep slopes should be seeded and mulched and/or covered.

Maintenance

- Inspect stabilized areas regularly, especially after large storm events. Add crushed rock if necessary and restabilize any areas found to be eroding.

  Removal of temporary measures. All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil areas resulting from removal shall be permanently stabilized.

DUST CONTROL

Symbol:

Definition:

Reducing surface and air movement of dust during land disturbing, demolition and construction activities.

Purpose:

To prevent surface and air movement of dust from exposed soil surfaces.

Conditions Where Practice Applies

- In areas (including roadways) subject to surface and air movement of dust where on-site and off-site damage is likely to occur if preventive measures are not taken.

Advantages

1. A decrease in the amount of dust in the air will decrease the potential for accidents and respiratory problems.

Disadvantages/Problems

1. Use of water on-site to control dust emissions, particularly in area where the soil is already compacted can cause a runoff problem where there wasn't one.

Planning Considerations

Construction activities inevitably result in the exposure and disturbance of soil. Fugitive dust is emitted both during the activities (i.e., excavation, demolition, vehicle traffic, human activity) and as a result of wind erosion over the exposed earth surfaces. Large quantities of dust are typically generated in "heavy" construction activities, such as road and street construction and subdivision, commercial and industrial development, which involve disturbance of significant areas of soil surface. Research at construction sites has established an average dust emission rate of 1.2 tons/acre/month for active construction. Earthmoving activities comprise the major source of construction dust emissions, but traffic and general disturbance of the soil also generate significant dust emissions.

In planning for dust control, remember that the less soil is exposed at any one time,the less potential there will be for dust generation. Therefore, phasing a project and utilizing temporary stabilization practices upon the completion of grading can significantly reduce dust emissions.

Design Criteria

- Minimize the period of soil exposure through use of temporary ground cover and other temporary stabilization practices (see Seeding and Mulching).

- Site is sprinkled with water until surface is wet. Repeat as needed. To prevent carry out of mud onto street, refer to Stabilized Construction Entrance.

- Spray exposed soil areas with approved dust palliative. Oil should not be used for dust

suppression. Check with the local government to see which other dust palliatives may be used in the area.

Maintenance

- Respray area as necessary to keep dust to a minimum.

PIPE SLOPE DRAINS

Symbol:

Definition:

A pipe extending from the top to the bottom of a cut or fill slope and discharging into a stabilized water course or a sediment trapping device or onto a stabilization area.

Purpose:

To carry concentrated runoff down steep slopes without causing gullies, channel erosion or saturation of slide-prone soils.

Protection of adjacent properties. Properties adjacent to the project site shall be protected from sediment deposition.

Cut and fill slopes. Cut and fill slopes shall be designed and constructed in a manner that will minimize erosion. In addition, slopes shall be stabilized.

Controlling off-site erosion. Properties and waterways downstream from development sites shall be protected from erosion due to increases in the volume, velocity and peak flow rate of stormwater runoff from the project site. While conducting land disturbing activities, limit the peak rate of runoff for the 5-year, 24-hour storm to 50 percent of the release rate for existing site conditions.

Stabilization of waterways and outlets. All temporary on site conveyance channels shall be designed and constructed to withstand the expected velocity of flow from a 5-year, 24-hour frequency storm for the developed condition without erosion. Stabilization adequate to prevent erosion of outlets, adjacent streambanks, slopes and downstream reaches shall be provided at the outlets of all pipes and channels.

Conditions Where Practice Applies

* Where a temporary (or permanent) measure is needed for conveying runoff down a slope without causing erosion.

Advantages

* Slope drains provide a potentially effective method of conveying water safely down steep slopes.

Disadvantages/Problems

* Care must be taken to correctly site the drain and not to under design them. Also, when clearing takes place prior to installing these drains, care must be taken to revegetate the entire easement area otherwise erosion tends to occur beneath the pipeline resulting in gully formation.

Planning Considerations

There is often a significant lag between the time a cut or fill slope is completed and the time a permanent drainage system can be installed. During this period the slope is usually not stabilized and

is particularly vulnerable to erosion. This situation also occurs on slope construction which is temporarily delayed before final grade is reached. Temporary slope drains can provide valuable protection of exposed slopes until permanent drainage structures can be installed. When used in conjunction with diversion dikes, temporary slope drains can be used to convey stormwater from the entire drainage area above a slope to the base of the slope without erosion. It is very important that these temporary structures be installed properly since their failure will often result in severe gully erosion. The entrance section must be securely entrenched, all connections must be watertight, and the conduit must be staked securely.

Design Criteria

- The capacity for temporary drains shall be sufficient to handle a 10-year, 24-hour peak flow. This may be computed using the Rational Method or other methods. Permanent pipe slope drains shall be sized for the 100-year, 24-hour peak flow.

- The maximum drainage area allowed per pipe is ten acres. For larger areas, a rock-lined channel or more than one pipe shall be installed (see Stormwater Conveyance Channels).

- The entrance shall consist of a standard flared end section for culverts 12 inches and larger with a minimum 6-inch metal toe plate to prevent runoff from undercutting the pipe inlet. The slope of the entrance shall be at least 3 percent.

- The soil around and under the pipe and entrance section shall be thoroughly compacted.

- The flared inlet section shall be securely connected to the slope drain and have watertight connecting bands.

- Slope drain sections shall be securely fastened together and have gasketed watertight fittings and be securely anchored into the soil.

- Interceptor dikes shall be used to direct runoff into a slope drain. The height of the dike shall be at least 1 foot higher at all points than the top of the inlet pipe.

- The area below the outlet must be stabilized with a riprap apron (see Outlet Protection for the appropriate outlet material).

- If the pipe slope drain is conveying sediment-laden water, direct all flows into the sediment trapping facility.

- Materials specifications for the type of pipe used shall be set by the local government.

Maintenance

- Check inlet and outlet points regularly and especially after heavy storms. The inlet should be free of undercutting and no water should be going around the point of entry. If there are problems, the headwall should be reinforced with compacted earth or sand bags. The outlet point should be free of erosion and installed with appropriate outlet protection.

Removal of temporary measures. All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil areas resulting from removal shall be permanently stabilized.

SUBSURFACE DRAINS

Symbol:

Definition:

A perforated conduit such as a pipe, tubing or tile installed beneath the ground to intercept and convey ground water.

Purpose:

To provide a dewatering mechanism for draining excessively wet, sloping soils--usually consisting of an underground perforated pipe that will intercept and convey ground water.

Protection of adjacent properties. Properties adjacent to the project site shall be protected from sediment deposition.

Dewatering construction sites. Dewatering devices shall discharge into a sediment trap or sediment pond. In no event shall sediment laden stormwater runoff cause a violation of turbidity or any other state water quality standards.

Stabilization of waterways and outlets. All temporary on-site conveyance channels shall be designed and constructed to withstand the expected velocity of flow from a 2-year, 24-hour frequency storm for the developed condition without erosion. Stabilization adequate to prevent erosion of outlets, adjacent streambanks, slopes and downstream reaches shall be provided at the outlets of all pipes and channels.

Conditions Where Practice Applies

- Wherever excessive water must be removed from the soil. The soil must be deep and permeable enough to allow an effective system to be installed.

Advantages

1. Subsurface drains often provide the only practical method of stabilizing excessively wet, sloping soils.

Disadvantages/Problems

1. Problems may be encountered with tree roots (see Maintenance).

2. Pipes cannot be located under heavy vehicle crossings.

Planning Considerations

Subsurface drainage systems are of two types; relief drains and interceptor drains. Relief drains are used either to lower the water table in order to improve the growth of vegetation or to remove surface water. They are installed along a slope and drain in the direction of the slope. They can be installed in a gridiron pattern, a herringbone pattern, or a random patters (see Figure 3).

Interceptor drains are used to remove water as it seeps down a slope, to prevent the soil from becoming saturated and subject to slippage. They are installed across a slope and drain to the side

of the slope. They usually consist of a single pipe or series of single pipes instead of a patterned layout (see Figure 3).

Design Criteria

Details:

- Subsurface drain shall be sized for the required capacity. The minimum diameter for a subsurface rain shall be 4 inches.
- The minimum velocity required to prevent silting is 1.4 ft/sec. The line shall be graded to achieve at least this velocity.
- Filter material and fabric shall be used around all drains for proper bedding and filtration of fine materials.
- The outlet of the subsurface drain shall empty into a sediment trap or pond. If free of sediment, it shall empty into a receiving channel, swale or stable vegetated area adequately protected from erosion and undermining.
- The strength and durability of the pipe shall meet the requirements of the site in accordance with the manufacturer's specifications.

Construction Specifications

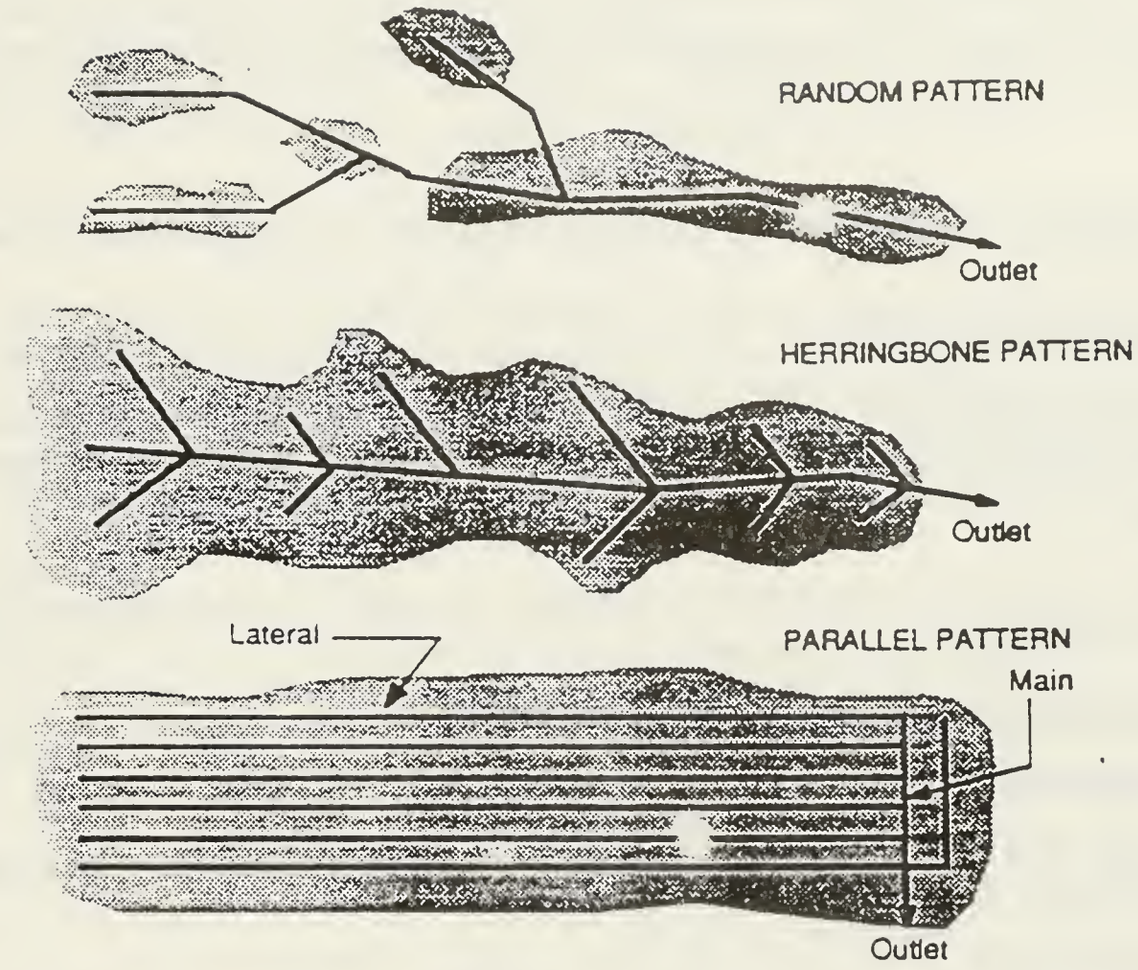
- The trench shall be constructed on a continuous grade with no reverse grades or low spots.
- Soft or yielding soils under the drain shall be stabilized with gravel or other suitable material.
- Deformed, warped or otherwise unsuitable pipe shall not be used.
- Filter material shall be placed as specified with at least 3 inches of material on all sides of the pipe.
- Backfilling shall be done immediately after placement of the pipe. No sections of pipe shall remain uncovered overnight or during a rainstorm. Backfill material shall be placed in the trench in such a manner that the drain pipe is not displaced or damaged.

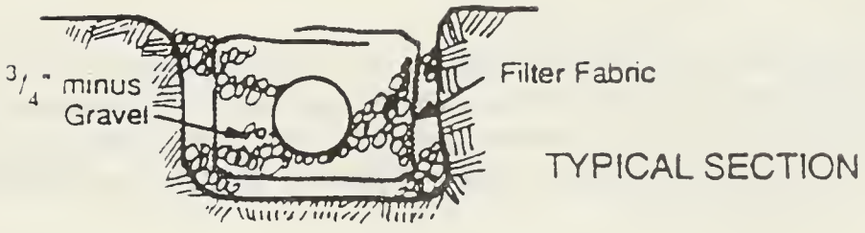
Maintenance

- Subsurface drains shall be checked periodically to ensure that they are free-flowing and not clogged with sediment.
- The outlet shall be kept clean and free of debris.
- Surface inlets shall be kept open and free of sediment and other debris.
- Trees located too close to a subsurface drain often clog the system with their roots. If a drain becomes clogged, relocate the drain or remove the trees.
- Where drains are crossed by heavy vehicles, the line shall be checked to ensure that it is not crushed.

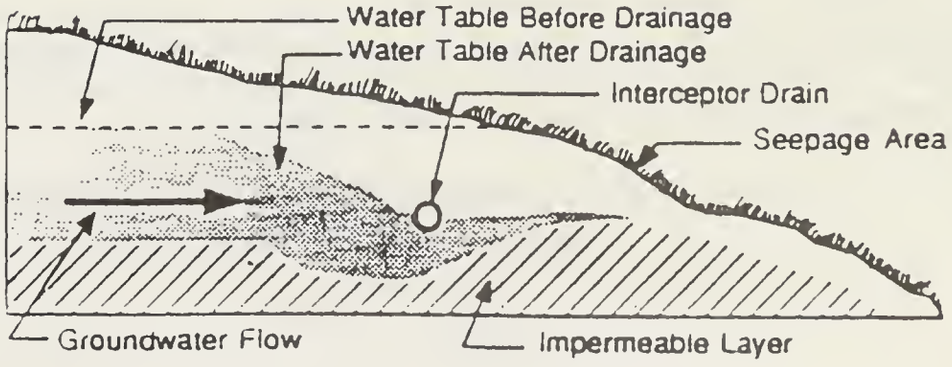
Removal of temporary measures. All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil areas resulting from removal shall be permanently stabilized.

Figure 3 Subsurface Drain Layout





TYPICAL SECTION



SURFACE ROUGHENING

Symbol:

Definition:

Provision of a rough soil surface with horizontal depressions created by operating a tiller or other suitable equipment on the contour or by leaving slopes in a roughened condition by not fine grading them.

Purpose:

To aid in establishment of vegetative cover, reduce runoff velocity ,increase infiltration and provide for sediment trapping.

Conditions Where Practice Applies

- All slopes steeper than 3:1 and greater than 5 vertical feet, require surface roughening, either stair-step grading, grooving, furrowing or tracking if they are to be stabilized with vegetation.

Advantages

1. Surface roughening provides some instant erosion protection on bare soil while vegetative cover is being established.

2. It is an inexpensive and simple erosion control measure.

Disadvantages/Problems

1. While this is a cheap and simple method of erosion control, it is of limited effectiveness in anything more than a moderate storm.

Planning Considerations

Graded areas with smooth, hard surfaces give a fall impression of "finished grading" and a job well done. It is difficult to establish vegetation on such surfaces due to reduced water infiltration and the potential for erosion. Rough slope surfaces with uneven soil and rocks left in place may appear unattractive or unfinished at first, but they encourage water infiltration, speed the establishment of vegetation and decrease runoff velocity.

Rough, loose soil surfaces give lime, fertilizer and seed some natural coverage. Niches in the surface provide microclimates which generally provide a cooler and more favorable moisture level than hard flat surfaces; this aids seed germination.

There are different methods for achieving a roughened soil surface on a slope and the selection of an appropriate method depends upon the type of slope. Roughening methods include stair-step grading, grooving and tracking. Factors to be considered in choosing a method are slope steepness, mowing requirements and whether the slope is formed by cutting or filling.

1. *Disturbed areas which will not require mowing may be stair-step graded, grooved or left rough after filling.*

2. *Stair-step grading is particularly appropriate in soils containing large amounts of softer rock. Each "step" catches material which sloughs from above, and provides a level site where vegetation can become established. Stairs should be wide enough to work with standard earth moving equipment.*

3. *Areas which will be mowed (these areas should have slopes less steep than 3:1) may have small furrows left by disking, harrowing, raking or seed-planting machinery operated on the contour.*

4. *It is important to avoid excessive compacting of the soil surface when scarifying. Tracking with bulldozer treads is preferable to not roughening at all, but is not as effective as other forms of roughening, as the soil surface is severely compacted and runoff is increased.*

Design Criteria

Graded ares with slopes greater than 3:1 but less than 2:1 should be roughened before seeding (Figure 4). This can be accomplished in a variety of ways, including "track walking," or driving a crawler tractor up and down the slope, leaving a pattern of cleat imprints parallel to slope contours.

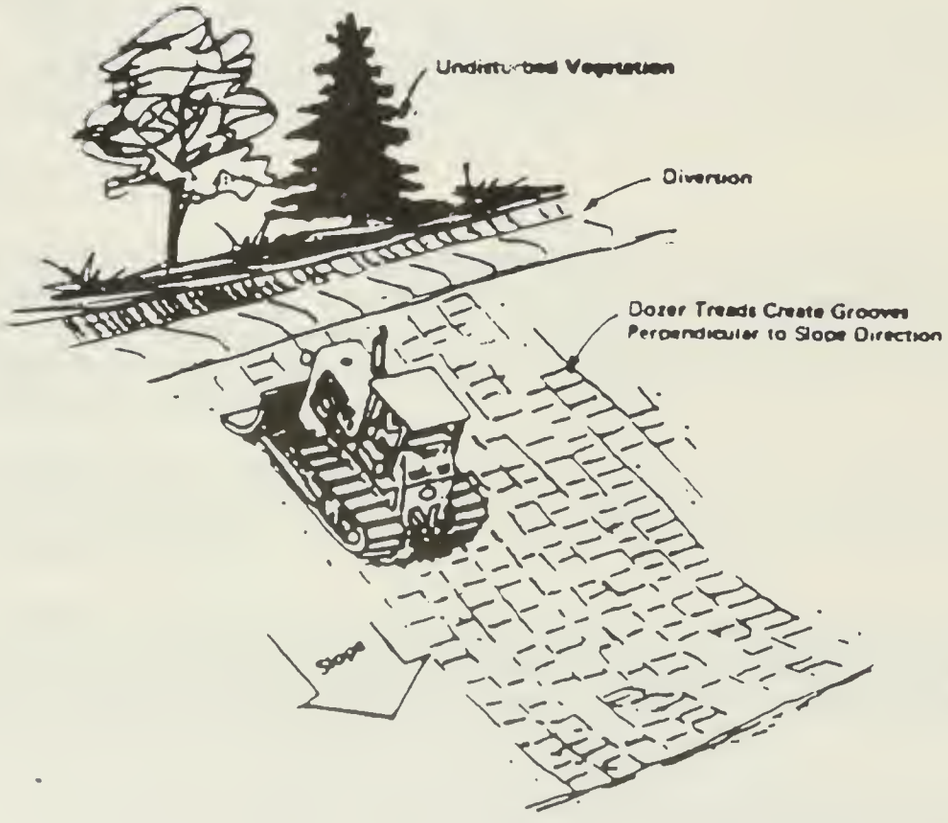
Graded areas steeper than 2:1 should be stair-stepped with benches as shown in Figure 5. The stair-stepping will help vegetation become established and also trap soil eroded from the slopes above.

Maintenance

- Areas which are graded in this manner should be seeded as quickly as possible.

- Regular inspections should be made of the area. If rills appear, they should be re-graded and re-seeded immediately.

Figure 4 Slope Roughening



GRADIENT TERRACES

Symbol:

Definition:

An earth embankment or a ridge-and-channel constructed with suitable spacing and with an acceptable grade.

Purpose:

To reduce erosion damage by intercepting surface runoff and conducting it to a stable outlet at a non-erosive velocity. (This standard covers the planning and design of gradient terraces and does not apply to diversions.)

Conditions Where Practice Applies

- Gradient terraces normally are limited to denuded land having a water erosion problem. They should not be constructed on deep sands or on soils that are too stony, steep, or shallow to permit practical and economical installation and maintenance. Gradient terraces may be used only where suitable outlets are or will be made available.

Advantages

1. Gradient terraces slow the velocity of runoff, increase the distance of overland flow and reduce effective hydraulic gradient. They also hold moisture and minimize sediment.

Disadvantages/Problems

1. May significantly increase cut and fill costs and cause sloughing if excessive water infiltrates soils.

Design Criteria

- The maximum spacing of gradient terraces should be determined by the following method: $V.I. = xs + y$

  Where: V.I. = vertical interval in feet
  x = 0.8
  s = land slope in feet per 100 feet
  y = a soil and cover variable with values from 1.0 to 4.0[1]

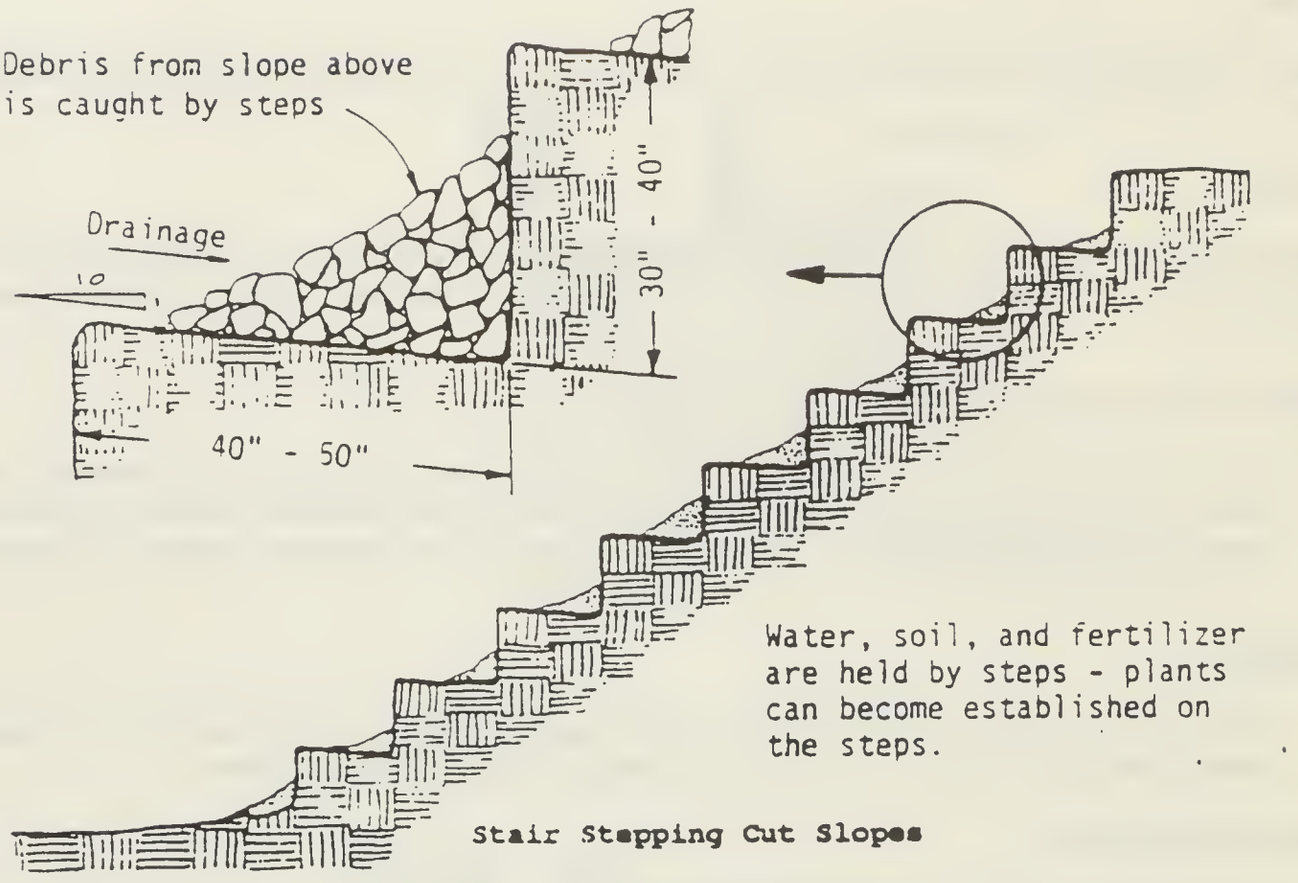
- The minimum constructed cross-section should meet the design dimensions.

- The top of the constructed ridge should not be lower at any point than the design elevation plus

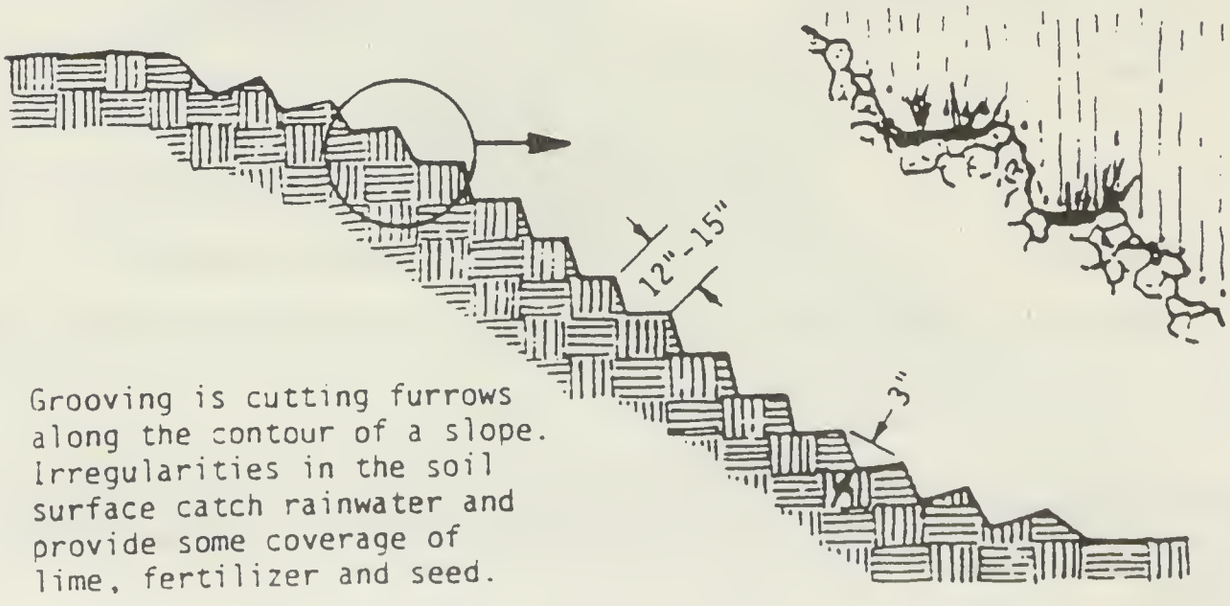
---

[1]Values of "y" are influenced by soil erodibility and cover practices. The lower values are applicable to erosive soils where little to no residue is left on the surface. The high value is applicable only to erosion resistant soils where a large amount of residue (1.5 tons of straw per acre equivalent) is on the surface.

Figure 5 Stair-stepping cut slopes


Debris from slope above is caught by steps
Drainage
10°
30" - 40"
40" - 50"
Water, soil, and fertilizer are held by steps - plants can become established on the steps.

Stair Stepping Cut Slopes


12" - 15"
3"
Grooving is cutting furrows along the contour of a slope. Irregularities in the soil surface catch rainwater and provide some coverage of lime, fertilizer and seed.

Grooving Slopes

the specified overfill for settlement. The opening at the outlet end of the terrace should have cross section equal to that specified for the terrace channel.

- Channel Grade - Channel grades may be either uniform or variable with a maximum grade of 0.6 feet per 100 feet length. For short distances, terrace grades may be increased to improve alignment. The channel velocity should not exceed that which is non-erosive for the soil type with the planned treatment.

- All gradient terraces should have adequate outlets. Such an outlet may be a grassed waterway, vegetated area or tile outlet. In all cases, the outlet must convey runoff from the terrace or terrace system to a point where the outflow will not cause damage. Vegetative cover should be used in the outlet channel.

- The design elevation of the water surface of the terrace should not be lower than the design elevation of the water surface in the outlet at their junction, when both are operating at design flow.

Specifications

- Vertical spacing determined by the above methods may be increased as much as 0.5 feet or 10 percent, whichever is greater, to provide better alignment or location, to avoid obstacles, to adjust for equipment size, or to reach a satisfactory outlet (Figure 6).

- The drainage area above the top should not exceed the area that would be drained by a terrace of equal length with normal spacing.

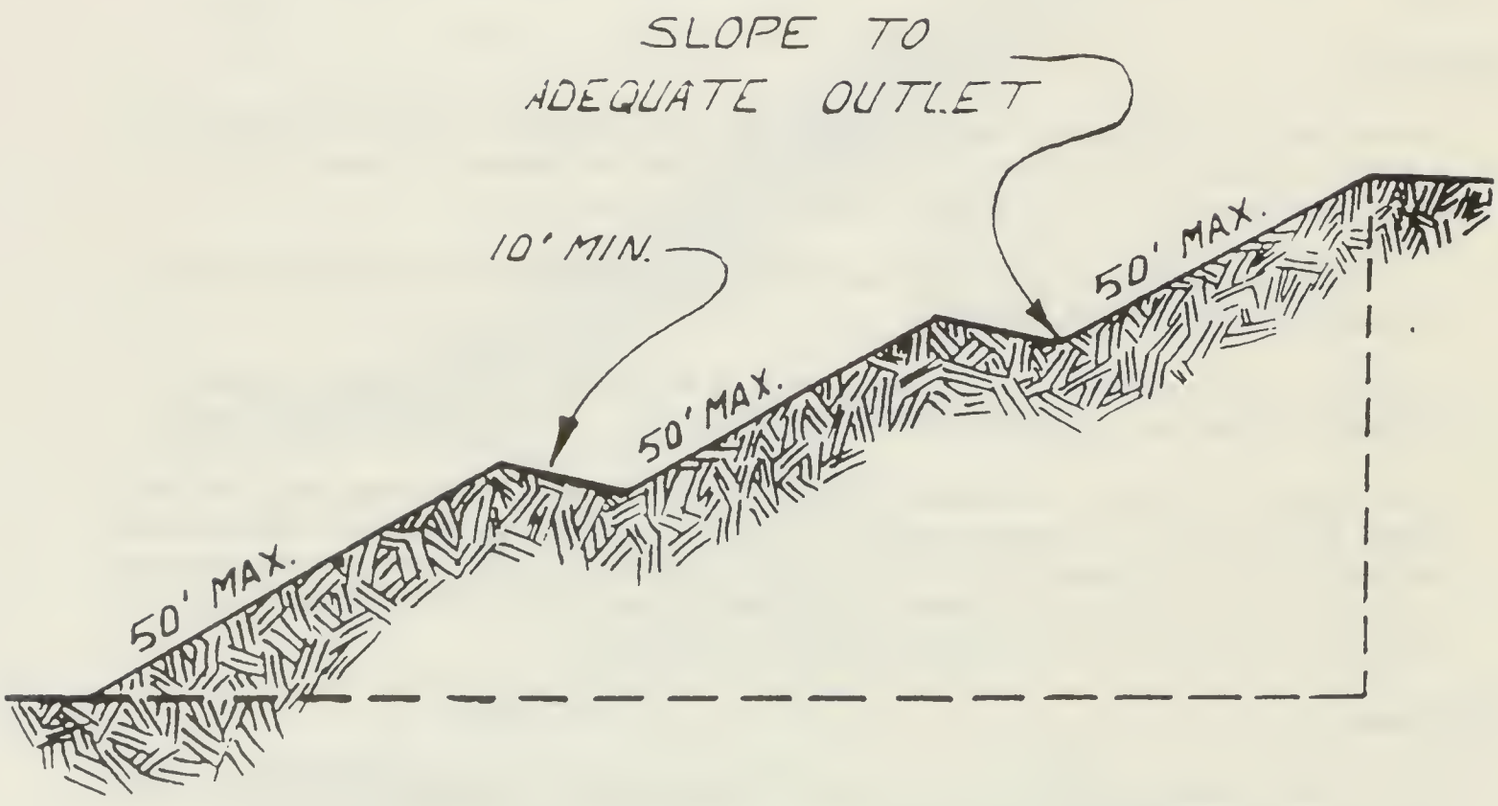
- Capacity - The terrace should have enough capacity to handle the peak runoff expected from a 10-year, 24-hour design storm without overtopping.

- Cross-Section - The terrace cross-section should be proportioned to fit the land slope. The ridge height should include a reasonable settlement factor. The ridge should have a minimum top width of 3 feet at the design height. The minimum cross-sectional area of the terrace channel should be 8 square feet for land slopes of 5 percent or less, 7 square feet for slopes from 5 to 8 percent and 6 square feet for slopes steeper than 8 percent.

Maintenance

- Maintenance should be performed as needed. Terraces should be inspected regularly; at least once a year and after large storm events.

Figure 6 Gradient Terraces



BIOENGINEERED PROTECTION OF VERY STEEP SLOPES

Symbol:

Definition:

Steep slope protection using a combination of vegetative and mechanical measures.

Purpose:

To stabilize steep banks.

Conditions Where Practice Applies

- Slopes of steep grade, cut and fill banks and unstable soil conditions that cannot be stabilized using ordinary vegetative techniques.

Advantages

1. Vegetation reduces sheet erosion on slopes and impedes sediment at the toe of the slope.

2. Where soils are unstable and liable to slip due to wet conditions, utilization of soil moisture by vegetation can reduce the problem.

3. Shrubs and trees shelter slopes against the impact of rainstorms and the humus formed by decaying leaves further helps to impede runoff.

4. Mechanical measures help to stabilize soil long enough to allow vegetation to become established.

Disadvantages/Problems

1. The planting of non-seeded material such as live willow brush is a specialized operation and cannot be highly mechanized or installed by unskilled labor.

2. The methods described are effective but require a complete knowledge of soil, hydrology and other physical data to design measures that will adequately solve the problem.

Design Criteria

The following bioengineering methods can be used after slopes have been protected by diversion of runoff or through the terracing of slopes.

- Sod walls or retaining banks are used to stabilize terraces. Sod is piled by tilting it slightly toward the slope and should be backfilled with soil and compacted as they are built up. Sod walls can be as steep as 1:8 but should not be higher than 5 feet (Figure 7).

- Timber frame stabilization is effective on gradients up to 1:1 and involves the following steps in construction: 1) Lay soil retarding frames of 2 x 4 inch vertical members and 1 x 4 horizontal members on slopes. Fames on slopes over 15 feet in length need to be anchored to slope to prevent buckling. 2) Attach 14 gauge galvanized tire wires for anchoring wire mesh. 3) Fill frames with moist topsoil and compact the soil. 4) Spread straw 6 inches deep over slope. 5)

Cover straw with 14 gauge 4-inch mesh galvanized reinforced wire. 6) Secure wire mesh at least 6 feet back of top slope.
7) Plant ground cover plants through straw into topsoil (Figure 7).

- Woven willow whips may be used to form live barriers for immediate erosion control. Construction: 1) 3 foot poles are spaced at 5 foot distances and driven into the slope to a depth of 2 feet. 2) 2 foot willow sticks are inserted between poles at one foot distances. 3) Live willow branches of 5 foot lengths are sunk to a depth of 1 inch and interwoven with poles and stocks. 4) Spaces between the woven "fences" are filled with topsoil. Fences are generally arranged parallel to the slope or in a grid pattern diagonal to the direction of the slope.

- Berm planting. 1) Excavate ditches from 3 to 5 feet apart along the slope and shape a berm on the downslope side. Construct ditches with 5 percent longitudinal slope. 2) Plant rooted cuttings on 3 foot centers and mulch. Suitable trees are willow, alder, birch, pine and selected shrubs. In extremely dry situations, rooted cuttings can be planted in biodegradable plastic bags that are watered at the time of planting.

- Brush Layers. 1) Prepare 3 foot "niches" as shown. 2) Lay unrooted 5 foot live branches of willow or poplar at close spacing. 3) starting at foot of slope, backfill lower ditch with excavated material from ditch above it. Operation should be carried out during dormant season.

Maintenance

- Regardless of the stabilization method used, inspections should be made on a regular basis to make sure the system is functioning correctly.

- Note: There are a number of manufacturers who provide prefabricated bioengineered devices for the protection of steep slopes.

Figure 7 - Sod Retaining Bank

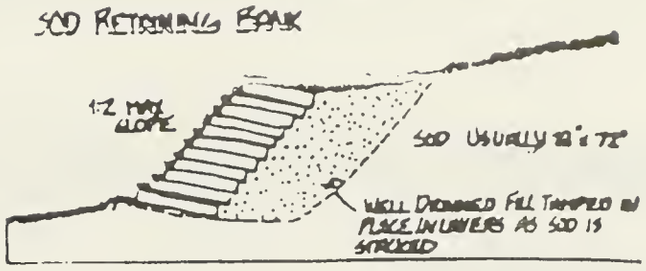


Figure II-4.10(a) Sod Retaining Bank

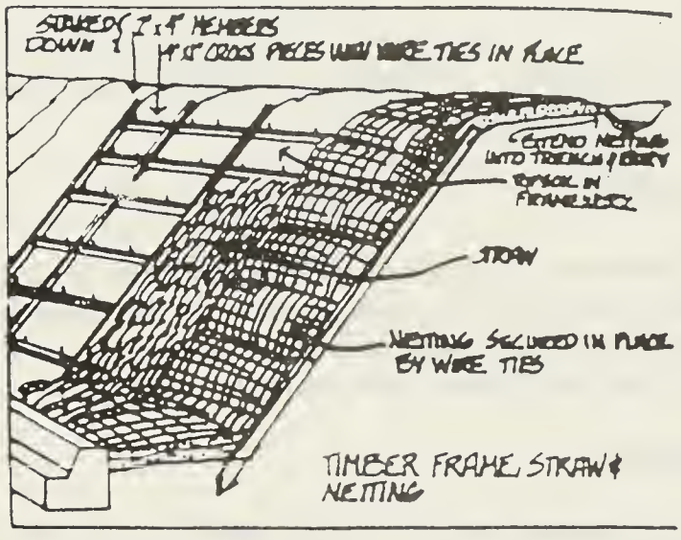

STAKES 2 x 4" MEMBERS DRIVEN
4'-0" CROSS PIECES WIRE TIES IN PLACE
EXTEND NETTING INTO TRENCH & ANCHOR
TOPSOIL IN FRAMEWORK
STRAW
NETTING SECURED IN PLACE BY WIRE TIES
TIMBER FRAME, STRAW & NETTING

Figure II-4.10(b) Timber Frame Stabilization

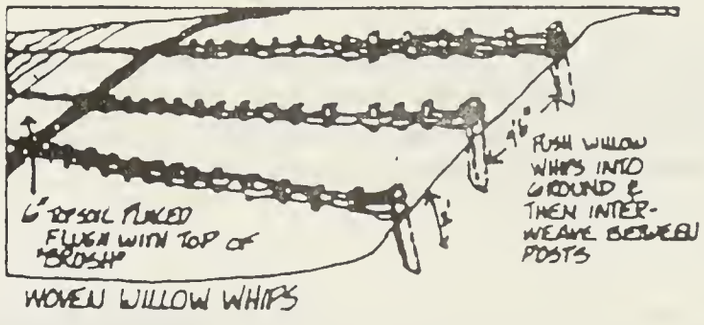
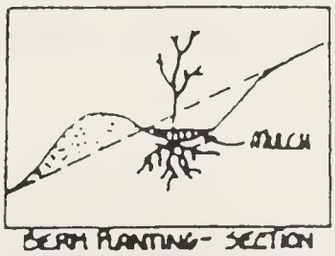
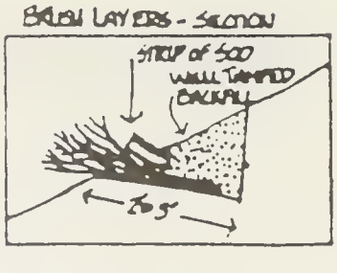

6" TOPSOIL PLACED FLUSH WITH TOP OF BROKEN
PUSH WILLOW WHIPS INTO GROUND & THEN INTER-WEAVE BETWEEN POSTS
WOVEN WILLOW WHIPS

Figure II-4.10(c) Woven Willow Whips





LEVEL SPREADER

Symbol:

Definition:

An outlet for dikes and diversions consisting of an excavated depression constructed at zero grade across a slope.

Purpose:

To convert concentrated runoff to sheet flow and release it onto areas stabilized by existing vegetation.

Conditions Where Practice Applies

- To be constructed on undisturbed areas that are stabilized by existing vegetation and where concentrated flows are anticipated to occur at 0 percent grade.

Advantages

- Level spreaders disperse the energy of concentrated flows, reducing erosion potential and encouraging sedimentation.

Disadvantages/Problems

- If the level spreader has any low points, flow tends to concentrate there. This concentrated flow can create channels and cause erosion. If the spreader serves as an entrance to a water quality treatment system, short-circuiting of the forebay may happen and the system will be less effective in removing sediment and particulate pollutants.

Planning Considerations

Interceptor dikes and swales call for a stable outlet for concentrated stormwater flows. The Level Spreader can be used for this purpose provided the runoff is relatively free of sediment. If properly constructed, the Level Spreader will significantly reduce the velocity of concentrated stormwater and spread it uniformly over a stable undisturbed area.

This practice is relatively easy and inexpensive to install. However, particular care must be taken during construction to ensure that the lower lip of the structure is level. If there are any depressions in the lip, flow will tend to concentrate at these points and erosion will occur, resulting in failure of the outlet. Regular maintenance is essential for this practice.

Design Criteria

- The grade of the channel for the last 20 feet of the dike or interceptor entering the level spreader shall be less than or equal to 1 percent. The grade of the level spreader shall be 0 percent to ensure uniform spreading of storm runoff.

- A 6-inch high gravel berm placed across the level lip shall consist of washed crushed rock, 2 to 4 inch or 3/4 inch to 1 1/2 inch size.

- The spreader length will be determined by estimating the flow expected from the 25-year, 24-hour design (Q_{26}) and selecting the appropriate length from the following table:

Q_{26} in CFS	Minimum Length in Feet
0.0 - 0.1	15
0.1 - 0.2	20
0.2 - 0.3	30
0.3 - 0.4	40

- The width of the spreader should be at least 6 feet.

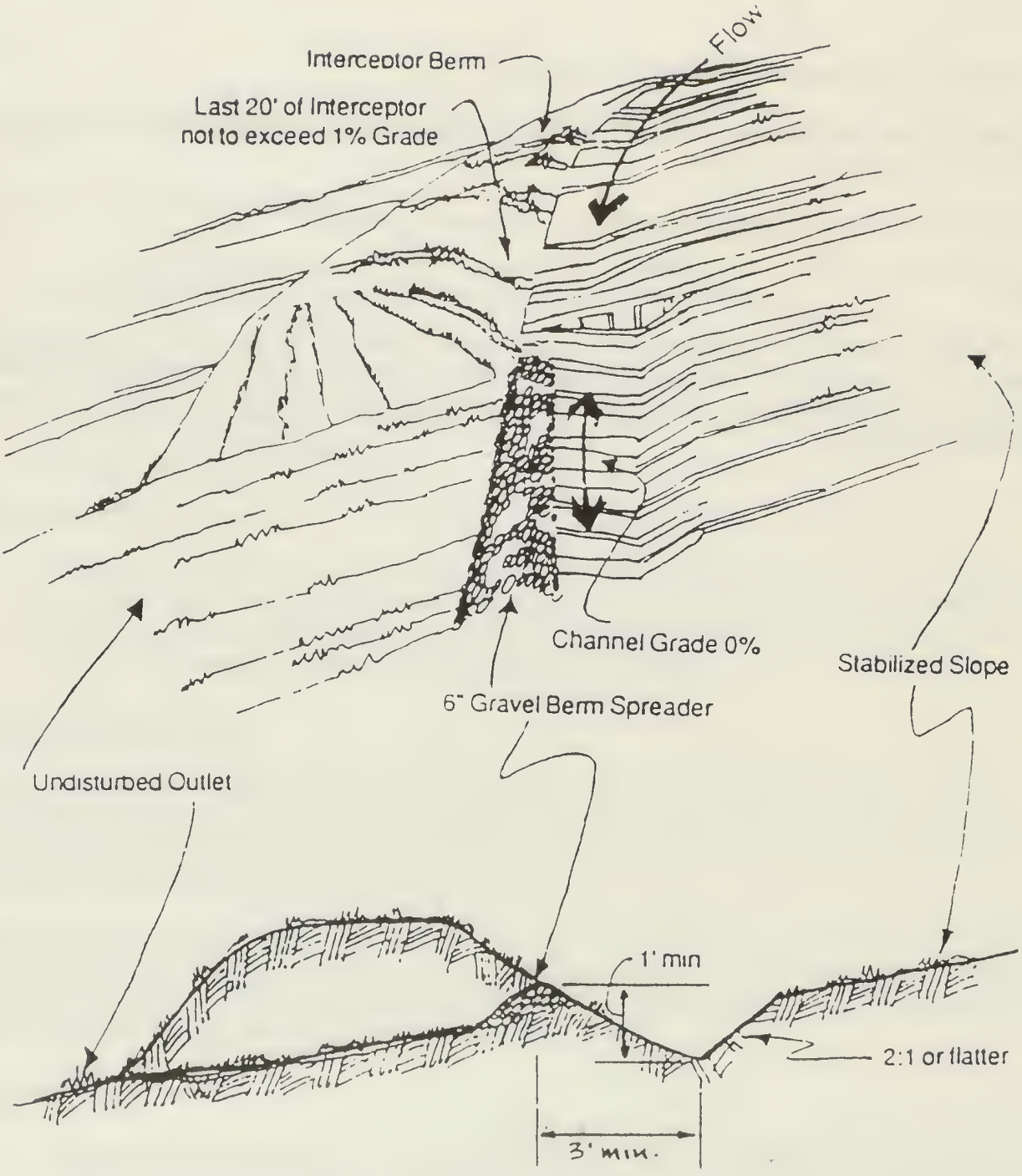
- The depth of the spreader as measured from the lip should be at least 6 inches and it should be uniform across the entire length.

- The slope of the undisturbed outlet should not exceed 20 percent.

Maintenance

- The spreader should be inspected after every runoff event to ensure that it is functioning correctly. The contractor should avoid the placement of any material on or prevent construction traffic across the structure. If the spreader is damaged by construction traffic, it shall be immediately repaired.

Figure 8 Level Spreader



INTERCEPTOR DIKE AND SWALE

Symbol:

Definition:

A ridge of compacted soil or a swale with vegetative lining located at the top or base of a sloping disturbed area.

Purpose:

To intercept storm runoff from drainage areas above unprotected slopes and direct it to a stabilized outlet.

Conditions Where Practice Applies

- Where the volume and velocity of runoff from exposed or disturbed slopes must be reduced. When an interceptor dike/swale is placed above a disturbed slope, it reduces the volume of water reaching the disturbed area by intercepting runoff from above. When it is placed horizontally across a disturbed slope, it reduces the velocity of runoff flowing down the slope by reducing the distance that the runoff can flow directly downhill.

Advantages

1. This BMP provides a practical, inexpensive method to divert runoff from erosive situations.

Disadvantages/Problems

1. None.

Planning Considerations

A temporary diversion dike or swale is intended to divert overland sheet flow to a stabilized outlet or a sediment trapping facility during establishment of permanent stabilization on a sloping disturbed area. When used at the top of a slope, the structure protects exposed slopes by keeping upland runoff away. When used at the base of a slope, the structure protects adjacent and downstream areas by diverting sediment-laden runoff to a sediment trapping facility.

If the dike or swale is going to remain in place for longer than 15 days, it shall be stabilized with temporary or permanent vegetation. The slope behind the dike or swale is also an important consideration. The dike or swale must have a positive grade to assure drainage, but if the slope is too great, precautions must be taken to prevent erosion due to high velocity of flow.

This practice is considered an economical one because it uses material available on the site and can usually be constructed with equipment needed for site grading. The useful life of the practice can be extended by stabilizing the dike or swale with vegetation.

Design Criteria

- Interceptor dikes shall meet the following criteria:

  Top width 2 feet minimum

Height 18 inches minimum. Measured from upslope toe and at a compaction of 90 percent ASTM D698 standard proctor.

Side slopes 2:1 or flatter

Grade Topography dependent, except that dike shall be limited to grades between .05 and 1.0 percent

Horizontal Spacing of Interceptor Dikes

Slopes <5% = 300 feet

Slopes 5-10% = 200 feet

Slopes 10-40% = 100 feet

Stabilization

Slopes <5% Seed and mulch applied within 5 days of dike construction.

Slopes 5-40% Dependent on runoff velocities and dike materials.

Outlet The upslope side of the dike shall provide positive drainage to the dike outlet. no erosion shall occur at the outlet. Provide energy dissipation measures as necessary. Sediment-laden runoff must be released through a sediment trapping facility.

Other Minimize construction traffic over temporary dikes.

- Interceptor swales shall meet the following criteria:

Bottom width 2 feet minimum; the bottom shall be level.

Depth 1 foot minimum.

Side slope 2:1 or flatter.

Grade Maximum 5 percent, with positive drainage to a suitable outlet (such as a sediment trap).

Stabilization Seed as per BMP 31.10 Temporary Seeding, or Rock: 12 inches thick pressed into the bank and extending at least 8 inches vertical from the bottom.

Swale spacing

Slope of disturbed area: Slopes <5% = 300 feet

Slopes 5-10% = 200 feet

Slopes 10-40% = 100 feet

Outlet Level spreader or riprap to stabilized outlet/sedimentation pond.

Maintenance

- The measure should be inspected after every major storm and repairs made as necessary. Damage caused by construction traffic or other activity must be repaired before the end of each working day.

Figure 9a. Temporary Interceptor Dikes

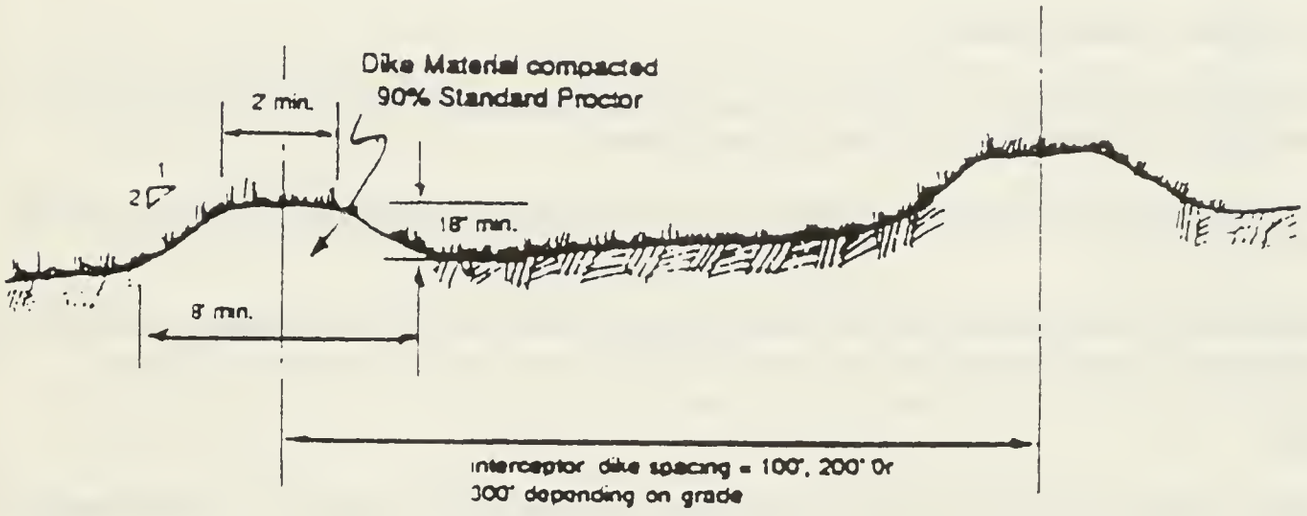
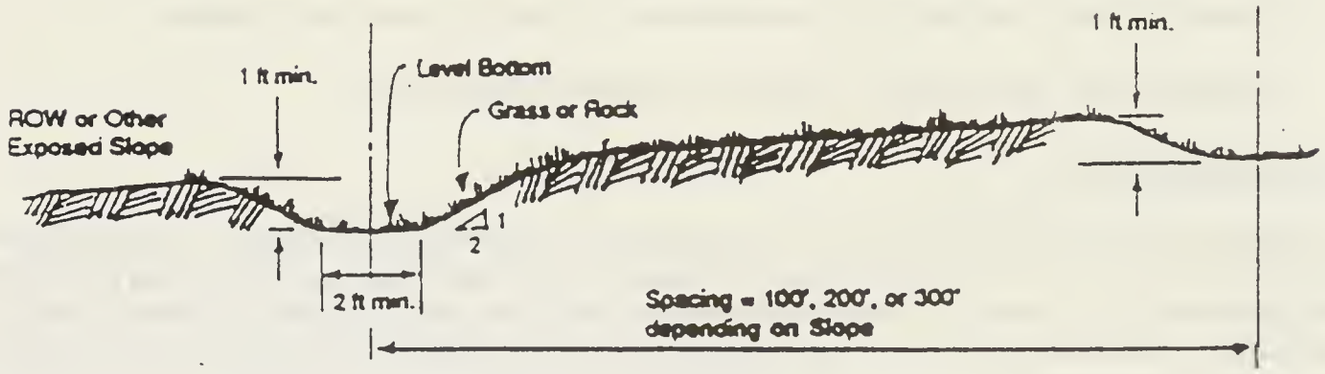


Figure 9b. Interceptor Swale



CHECK DAMS

Symbol:

Definition:

Small dams constructed across a swale or drainage ditch.

Purpose:

To reduce the velocity of concentrated flows, reducing erosion of the swale or ditch and to slow water velocity to allow retention of sediments.

Conditions Where Practice Applies

- Where temporary channels or permanent channels are not yet vegetated, channel lining is infeasible and, therefore, velocity checks are required.
- No check dams may be placed in streams unless approved by the State Department of Fish, Wildlife and Parks.
- Check dams in association with sumps work more effectively at slowing flow and retaining sediment.

Advantages

1. Check dams not only prevent gully erosion from occurring before vegetation is established, but also cause a high proportion of the sediment load in runoff to settle out.
2. In some cases, if carefully located and designed, these check dams can remain as permanent installations with very minor regrading, etc. They may be left as either spillways, in which case accumulated sediment would be graded and seeded, or as check dams to precipitate further sediment coming off that site.

Disadvantages/Problems

1. Because of their temporary nature, many of these measures are unsightly and they should be removed or converted to permanent check dams before dwelling units are rented or sold.
2. Removal may be a significant cost depending on the type of check dam installed.
3. Temporary check dams are only suitable for a limited drainage area.

Planning Considerations

Check dams can be constructed of either stone, logs, or pea gravel filled sandbags. Log check dams may be more economical from the standpoint of material costs, since logs can often be salvaged from clearing operations. However, log check dams require more time and hand labor to install. Stone for check dams, on the other hand, must generally be purchased. However, this cost is offset somewhat by the ease of installation.

If stone check dams are used in grass-lined channels which will be moved, care should be taken to

remove all the stone from the channel when the dam is removed. This should include any stone which has washed downstream. Since log check dams are embedded in the soil, their removal will result in more disturbance of the soil than will removal of stone check dams. Consequently, extra care should be taken to stabilize the area when log dams are used in permanent ditches or swales.

Design Criteria

- Check dams can be constructed of either rock or logs. Provide a deep sump immediately upstream.

- The maximum spacing between the dams shall be such that the toe of the upstream dam is at the same elevation as the top of the downstream dam.

- Rock check dams shall be constructed of appropriately sized rock. The rock must be placed by hand or mechanical placement (no dumping of rock to form dam) to achieve complete coverage of the ditch or swale and to ensure that the center of the dam is lower than the edges. The rock used must be large enough to stay in place given the expected design flow through the channel.

- Log check dams shall be constructed of 4 to 6-inch diameter logs. The logs shall be embedded into the soil at least 18 inches.

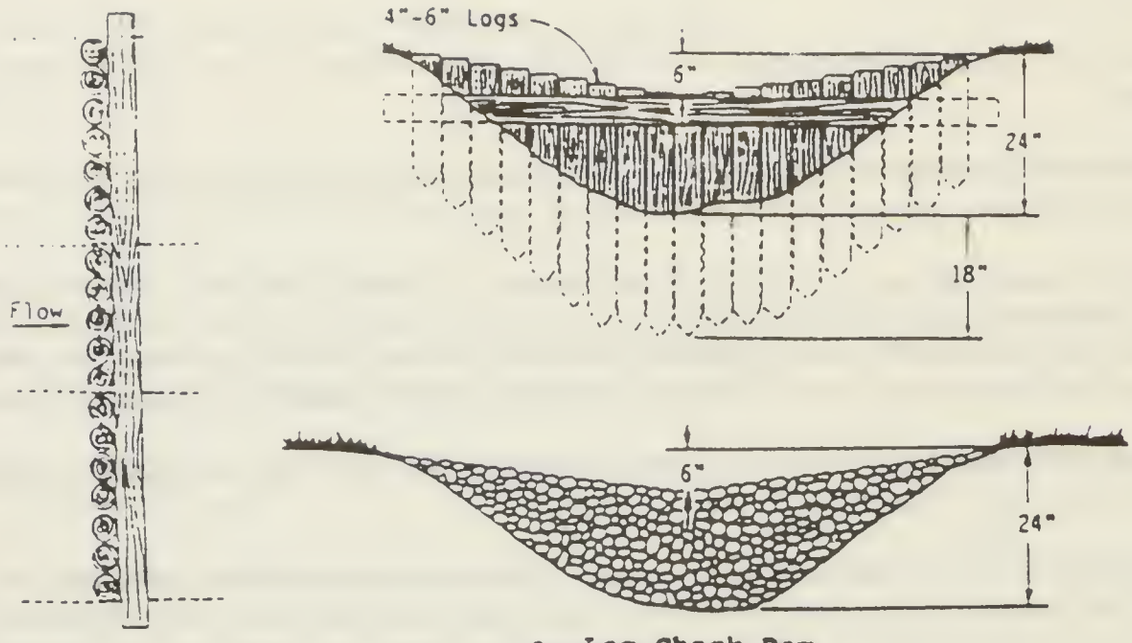
- In the case of grass-lined ditches and swales, check dams shall be removed when the grass has matured sufficiently to protect the ditch or swale unless the slope of the swale is greater than 4 percent. The area beneath the check dams shall be seeded and mulched immediately after dam removal.

Maintenance

- Check dams shall be monitored for performance and sediment accumulation during and after each runoff producing rainfall. Sediment shall be removed when it reaches one half the sump depth.

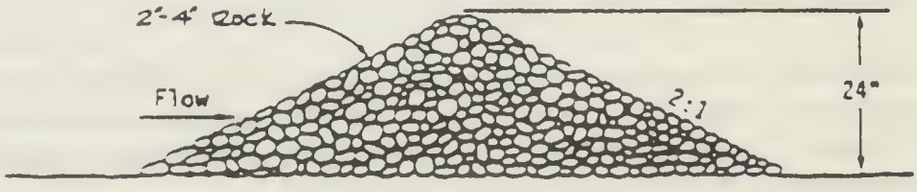
Removal of temporary measures. All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil areas resulting from removal shall be permanently stabilized.

Figure 10 Check Dams



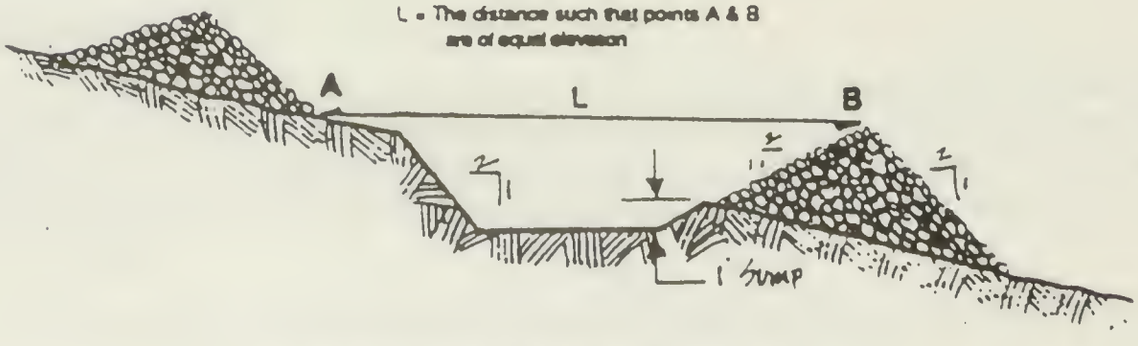
a. Log Check Dam

NO SCALE



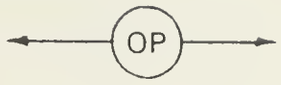
b. Rock Check Dam

NO SCALE



c. Spacing Between Check Dams

OUTLET PROTECTION

Symbol: 

Definition:

Structurally lined aprons or other acceptable energy dissipating devices placed at the outlets or pipes or paved channel sections.

Purpose:

To prevent scour at stormwater outlets and to minimize the potential for downstream erosion by reducing the velocity of concentrated stormwater flows.

Controlling off-site erosion. Properties and waterways downstream from development sites shall be protected from erosion due to increases in the volume, velocity and peak flow rate of stormwater runoff from the project site. While conducting land disturbing activities, limit the peak rate of runoff for the 2-year, 24-hour storm to 50 percent of the release rate for existing site conditions.

Stabilization of waterways and outlets. All temporary on-site conveyance channels shall be designed and constructed to withstand the expected velocity of flow from a 2-year, 24-hour frequency storm for the developed condition without erosion. Stabilization adequate to prevent erosion of outlets, adjacent streambanks, slopes and downstream reaches shall be provided at the outlets of all pipes and channels.

Conditions Where Practice Applies

- Applicable to the outlets of all pipes, interceptor swale outlets and channel sections where the velocity of flow at the design capacity of the outlet will exceed the permissible velocity of the receiving channel or area.

Advantages

1. Plunge pools which can develop without outlet protection may severely weaken the embankment and thus threaten its stability.

2. Protection can prevent scouring at a culvert mouth and thus prevent gully erosion which may gradually extend upstream.

Disadvantages/Problems

1. Some types of structures may be unsightly.

Planning Considerations

An outfall is defined as a concentrated discharge point which directs collected surface water flows into an open drainage feature, natural or manmade. These drainage features include ditches, channels, swales, closed depressions, wetlands, streams, rivers, ponds, lakes or other open bodies of water. In nearly every case, the outfall will consist of a pipe discharging flows from a storm pipe system, a culvert or a detention facility.

RIPRAP

Symbol:

Definition:

A permanent, erosion-resistant ground cover of large, loose, angular stone.

Purpose:

To slow the velocity of concentrated runoff or to stabilize slopes with seepage problems and/or non-cohesive soils by placement of large, loose, angular stone.

Controlling off-site erosion. Properties and waterways downstream from development sites shall be protected from erosion due to increases in the volume, velocity and peak flow rate of stormwater runoff from the project site. While conducting land disturbing activities, limit the peak rate of runoff for the 2-year, 24-hour storm to 50 percent of the release rate for existing site conditions.

Stabilization of waterways and outlets. All temporary on-site conveyance channels shall be designed and constructed to withstand the expected velocity of flow from a 2-year, 24-hour frequency storm for the developed condition without erosion. Stabilization adequate to prevent erosion of outlets, adjacent streambanks, slopes and downstream reaches shall be provided at the outlets of all pipes and channels.

Conditions Where Practice Applies

- Soil-water interfaces, where the soil conditions, water turbulence, water velocity and expected vegetative cover, are such that the soil may erode under the design flow conditions.

Advantages

1. Riprap offers an easy-to-use method of decreasing water velocity and protecting slopes from erosion. It is simple to install and maintain.

2. Riprap provides some water quality benefits by increasing roughness and decreasing the velocity of the flow, inducing settling.

Disadvantages/Problems

1. Riprap is more expensive than vegetated slopes.

Planning Considerations

Riprap is classified as either graded or uniform. A sample of graded riprap would contain a mixture of stones which vary in size from small to large. A sample of uniform riprap would contain stones which are all fairly close in size.

For most applications, graded riprap is preferred to uniform riprap. Graded riprap forms a flexible self-healing cover, which uniform riprap is more rigid and cannot withstand movement of the stones. Graded riprap is cheaper to install, requiring only that the stones be dumped so that they remain in a well-graded mass. Hand or mechanical placement of individual stones is limited to that necessary to achieve the proper thickness and line. Uniform riprap requires placement in a more or less uniform

patter, requiring more hand or mechanical labor. Riprap sizes can be designated by either the diameter or the weight of the stones. It is often misleading to think of riprap in terms of diameter, since the stone should be rectangular instead of spherical. However, it is simpler to specify the diameter of an equivalent size of spherical stone. Table 2 below lists some typical stones by weight, spherical diameter and the corresponding rectangular dimensions. These stone sizes are based upon a assumed specific weight or 165 lbs./ft^3.

Design Criteria

TABLE 2 Size of Riprap Stones

Weight (lbs)	Diameter (ft)	Length (ft)	Width Height (ft)
50	0.8	1.4	0.5
100	1.1	1.75	0.6
150	1.3	2.0	0.67
300	1.6	2.6	0.9
500	1.9	3.0	1.0
1,000	2.2	3.7	1.25
1,500	2.6	4.7	1.5
2,000	2.75	5.4	1.8
4,000	3.6	6.0	2.0
6,000	4.0	6.9	2.3
8,000	4.5	7.6	2.5
20,000	6.1	10.0	3.3

Since graded riprap consists of a variety of stone sizes, a method is needed to specify the size range of the mixture of stone. This is done by specifying a diameter of stone in mixture for which some percentage, by weight, will be smaller. For example, d refers to a mixture of stones in which 85 percent of the stone by weight would be smaller than the diameter specified. Most designs are based on d. In other words, the design is based on the median size of stone in the mixture.

Sequence of Construction

Since riprap is used where erosion potential is high, construction must be sequenced so that the riprap is put in place with the minimum possible delay. Disturbance of areas where riprap is to be placed should be undertaken only when final preparation and placement of the riprap can follow immediately behind the initial disturbance. Where riprap is used for outlet protection, the riprap should be placed before or in conjunction with the construction of the pipe or channel so that it is in place when the pipe or channel begins to operate.

Maintenance

- Riprap coverings should be inspected on a regular basis and after every large storm event.

All temporary and permanent erosion and sediment control practices shall be maintained and repaired as needed to assure continued performance of their intended function.

VEGETATIVE STREAMBANK STABILIZATION

Symbol:

Definition:

The use of vegetation to stabilize streambanks.

Purpose:

To protect streambanks against erosion through vegetative means.

Controlling off-site erosion. Properties and waterways downstream from development sites shall be protected from erosion due to increases in the volume, velocity and peak flow rate of stormwater runoff from the project site. While conducting land disturbing activities, limit the peak rate of runoff for the 2-year, 24-hour storm to 50 percent of the release rate for existing site conditions.

Stabilization of waterways and outlets. All temporary on-site conveyance channels shall be designed and constructed to withstand the expected velocity of flow from a 2-year, 24-hour frequency storm for the developed condition without erosion. Stabilization adequate to prevent erosion of outlets, adjacent streambanks, slopes and downstream reaches shall be provided at the outlets of all pipes and channels.

Conditions Where Practice Applies

- Application to water areas and all land uses. To be used to stabilize banks in swales, creeks, streams and rivers as well as man-made ditches, canals and impoundments, including ponds and storage basins.

Advantages

1. Streambank vegetation can break wave action and the velocity of flood flows.

2. Roots and rhizomes stabilize streambanks.

3. The reduction of velocity can lead to the deposit of water-borne soil particles.

4. Certain reeds and bulrushes have the capability of improving water quality by absorbing certain pollutants such as heavy metals, detergents, phenols and indols (1).

5. Plants regenerate themselves and adapt to changing natural situations, thus offering a distinct economic advantage over mechanical stabilization.

6. Benefits of wildlife and fisheries habitat improvement.

Disadvantages/Problems

1. Native plants may not be carried by regular nurseries and may need to be collected by hand or obtained from specialty nurseries.

2. Flow retarding aspects of vegetated waterways need to be taken into account.

Planning Considerations

A primary cause of stream channel erosion is the increased frequency of bank-full flows which often results from upstream development. Most natural stream channels are formed with a bank-full capacity to pass the runoff from a storm with a 1.5 to 2-year recurrence interval. However, in a typical urbanizing watershed, stream channels may become subject to a 3 to 5-fold increase in the frequency of bank-full flows if the stormwater runoff is not properly managed. As a result, stream channels that were once parabolic in shape and covered with vegetation may be transformed into wide rectangular channels with barren banks.

In recent years, a number of structural measures have evolved to strengthen and protect the banks of rivers and streams. These methods, when employed correctly, immediately ensure a satisfactory protection of the banks. However, many such structures are expensive to build and to maintain. Without constant upkeep, they are exposed to progressive deterioration by natural agents. The materials used often prevent reestablishment of native plants and animals, especially when the design is executed according to standard cross-sections which ignore natural variations of the stream system. Very often these structural measures destroy the appearance of the site. Additionally, structural stabilization and channelization can alter the hydrodynamics of a stream and only serve to transfer erosion potential and associated problems downstream.

In contrast, the utilization of living plants instead of or in conjunction with structures has many advantages. The degree of protection, which may be low to start with, increases as the plants grow and spread. The repair and maintenance of structures is unnecessary where self-maintaining streambank plants are established. The protection provided by natural vegetation is more reliable and effective when the cover consists of natural plant communities adapted to their site.

Design Criteria

- Design must be prepared based on criteria and input/review by a qualified fisheries biologist.

- Streambanks can be divided into: 1) aquatic plant zones at the mean low-water level; 2) reed bank zones covered at bankfull stage; 3) lower riparian zones or open floodway zones naturally covered with willows and shrubbery plants; 4) upper riparian areas or flood fringe areas that would naturally be covered with canopy-forming trees (see Figure 11).

- Aquatic plants can often considered weeds and a nuisance through they do slow down streamflow and protect the streambed. Primary emphasis of streambank stabilization lies in the bankfull zone.

- The reed bank zone forms a permeable obstacle, slowing down current waves by friction. Suitable plants can be found by consulting the Department of Fish, Wildlife and Parks or the Soil Conservation Service. Their shoots, with a root clump, can be planted in pits at 1/2 to a 1 foot depth below water, or in a reed roll as in Figure 11. A trench 1 1/2 feet wide and deep is dug behind a row of stakes; wire netting is then stretched from both sides between upright planks; coarse gravel is dumped on this and covered with reed clumps until the two edges of the netting can just be held together with wire. The upper edge of the roll should not be more than 2 inches above water level. Finally, the planks are taken out and gaps in the ditch are backfilled.

- The lower riparian zone has a natural growth of willow, alder, cottonwood, small maples and various berries. These vegetative types can be reintroduced on denuded floodplains to stabilize

the soil with their roots. In periods of high water, their upper branches reduce the speed of the current and thereby the erosive force of water. The most commonly used vegetative stabilizer for this zone is willow because of its capability to develop secondary roots on cut trunks and to throw up suckers. Willows are planted either as individual cuttings bound together in various forms or wired together in "fascines."

- Fascines have a diameter of 3 to 12 inches and contain brushwood and sticks and coarse gravel or rubble in the center tightly wound around. Packed fascine-work can be employed on cut banks. It consists of 1 foot layers of branches covered with young, freshly cut shoots secured by stakes. The spaces between the shoots are filled with dirt and another layer is added on top. Another technique is the use of willow mattresses made from 4 to 6 foot willow switches set into 6-inch trenches held down by stakes that are braided or wired together. The entire mattress is lightly covered with dirt. A variation of this method is the brush-mesh technique which is designed to stabilize breached cut banks and to encourage the deposition of sediment. It involves the following steps:

  1. Placement of poles at 10 foot distance;

  2. Placement of large branches and brush facing the stream;

  3. Setting cuttings of live willow branches between the brush vertically; and

  4. Securing vertical willows with cuttings set diagonally facing the streamflow.

- Slip banks of the lower riparian zone and tidal banks can be stabilized with grass (3). First the bank needs to be graded to a maximum slope of 3:1. Topsoil should be conserved for reuse, lime (2 tons/acre) and fertilizer (1,000 lbs/acre of 10:10:10) should be applied. Coarse grass and beach grass should be planted at the water's edge to trap drift sand; and bermuda grass, suitable for periodic inundation, should occupy the face of the slope, followed by tall fescue on higher ground.

Maintenance

- Streambanks are always vulnerable to new damage. Repairs are needed periodically. Banks should be checked after every high-water event is over. Gaps in the vegetative cover should be fixed at once with new plants and mulched if necessary. Fresh cuttings from other plants on the bank can be used or they can be taken from mother-stock plantings if they are available.

All temporary and permanent erosion and sediment control practices shall be maintained and repaired as needed to assure continued performance of their intended function.

References

(1) Seibert, P., Importance of Natural Vegetation for the Protection of the Banks of Streams, Rivers, and Canals, Freshwater, the Council of Europe. Manhattan Publishing Co., New York, 1968.

(2) U.S. Soil Conservation Service, Interim Standards and Specifications for Vegetative Tidal Bank Stabilization, College Park, Maryland, 1969.

(3) Schiectl, Hugo, Bioengineering for Land Reclamation and Conservation, p. 404, University of Alberta Press, 1980.

Effect of Vegetation on Stormwater Runoff

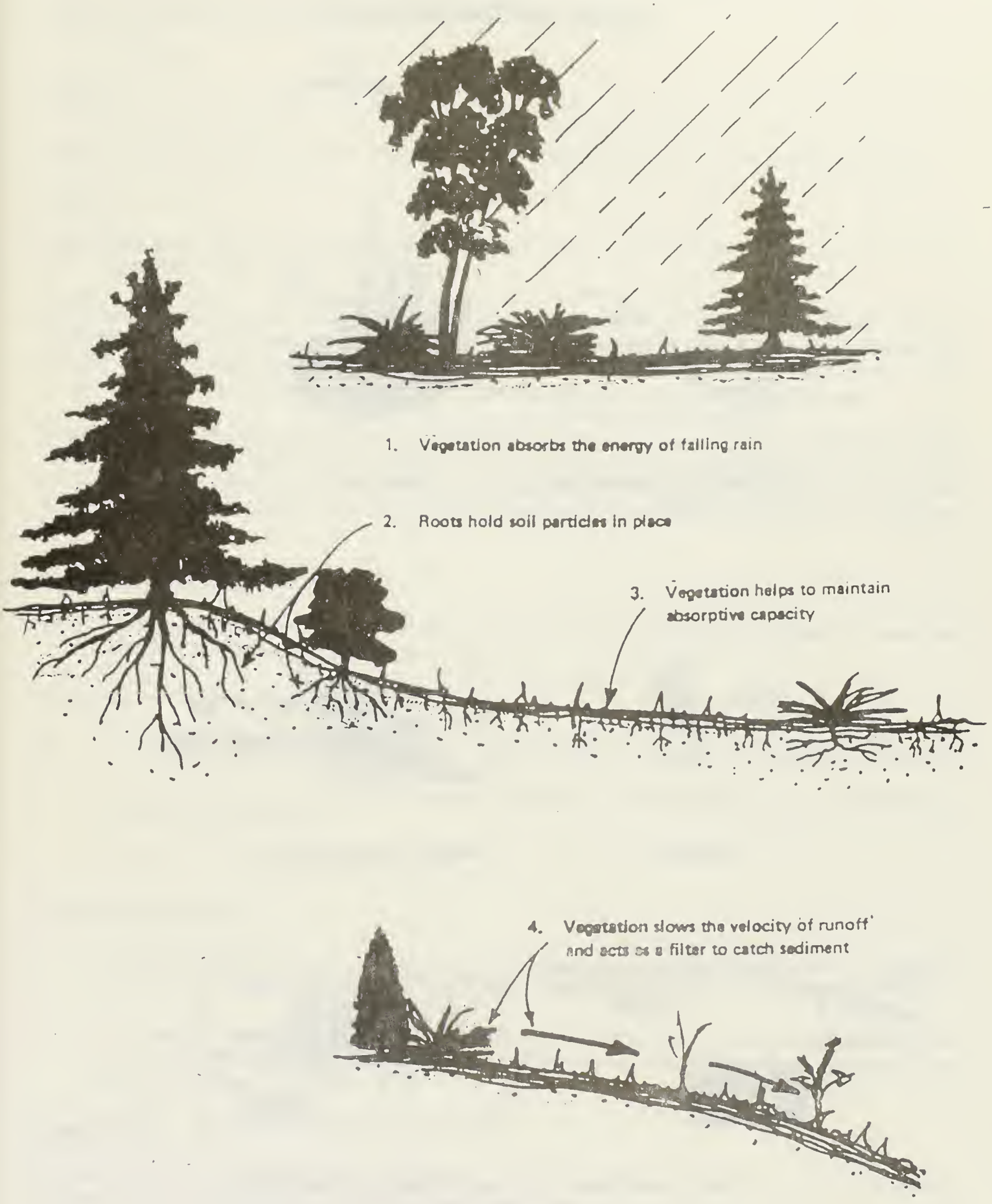
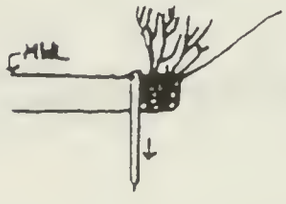

1. Vegetation absorbs the energy of falling rain
2. Roots hold soil particles in place
3. Vegetation helps to maintain absorptive capacity
4. Vegetation slows the velocity of runoff and acts as a filter to catch sediment

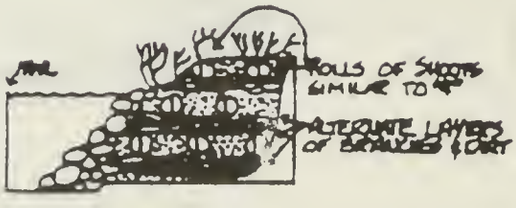
Figure 11 Streambank Stabilization

Streambank Vegetative Zones

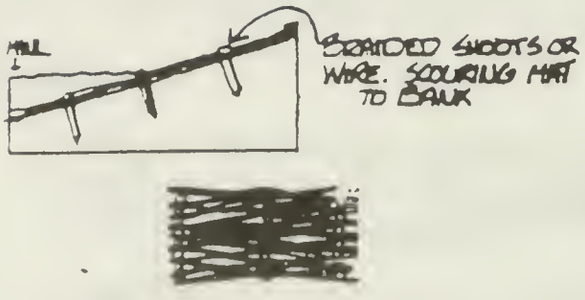
Reed Roll



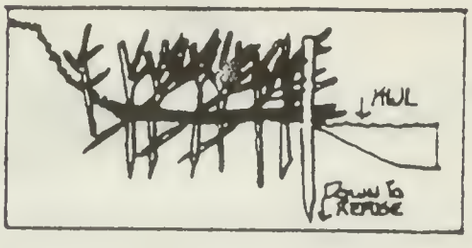
Fascines



Packed Fascine-Work



Willow Mattress



Brush-Mesh Protection

BIOENGINEERING METHODS OF STREAMBANK STABILIZATION

Symbol:

Definition:

Methods of stabilizing streambanks through a combination of vegetative and mechanical means.

Purpose:

To provide protection of critical sections of streambank where ordinary vegetative means of protection are not feasible or offer insufficient protection.

Controlling off-site erosion. Properties and waterways downstream from development sites shall be protected from erosion due to increases in the volume, velocity and peak flow rate of stormwater runoff from the project site. While conducting land disturbing activities, limit the peak rate of runoff for the 2-year, 24-hour storm to 50 percent of the release rate for existing site conditions.

Stabilization of waterways and outlets. All temporary on-site conveyance channels shall be designed and constructed to withstand the expected velocity of flow from a 2-year, 24-hour frequency storm for the developed condition without erosion. Stabilization adequate to prevent erosion of outlets, adjacent streambanks, slopes and downstream reaches shall be provided at the outlets of all pipes and channels.

Conditions Where Practice Applies

- To be used in streams with swift flow where the flow/soil conditions exceed the stabilizing effect of purely vegetative channel protection.

Advantages

1. Mechanical materials provide for interim and immediate stabilization until vegetation takes over.

2. Once established, vegetation can outlast mechanical structures and requires little maintenance while regenerating itself.

3. Aesthetic benefits and wildlife habitat.

Disadvantages/Problems

1. Slightly higher initial cost and need for professional advice. (It is recommended that the services of a qualified bioengineer be sought for this work.)

2. The methods described are effective but require a complete knowledge of soils, hydrology and other physical data to design measures that will adequately solve the problem and stand up to the test of time.

Design Criteria

Streams in urban settings may carry an increase in runoff of such great magnitude that they cannot be maintained in a natural state. In these cases bioengineering methods can provide for stabilization without complete visual degradation and higher effectiveness than purely mechanical techniques. This

applies primarily to: 1) the reed bank zone (BF) and 2) the lower riparian zone (OF). The following techniques apply to the reed bank zone:

Reed berms consisting of a combination of reeds and riprap, break wave action and erosion of banks by currents. Banks should not exceed a 2:1 slope. Riprap is placed to form a berm that extends beyond the surface at mean low-water level, separating the reed bed from the body of water.

Willow jetties can be constructed at the water level to stabilize a cut bank by deflecting the current and by encouraging deposition of sediment. Steps:

1. Dig ditches diagonally to direction of flow and place fill to form berm downstream from ditch.

2. Set 2-foot willow branches (4 feet may be needed) at 45° angle and 3-inch spacing facing downstream.

3. Weight down branches with riprap extending beyond water level.

Willow gabions can be used when a hard-edged effect is desired to deflect the eroding flow of water. Live willow branches, pointing downstream, are inserted through the wire mesh when the gabion is packed with stone and an addition of finer materials. Branches need to be long enough to extend through the gabion into the soil of the bank. They also should be placed at an angle back into the slope.

Piling revetment with wire facings is especially suited for the stabilization of cut banks with deep water. It involves the following steps:

1. Drive heavy timbers (8-12 inch diameter) on 6 to 8-foot centers along bank to be protected to point of refusal or one half length of pile below maximum scour.

2. Fasten heavy wire fencing to the post and if the streambed is subject to scour, extend it horizontally on the streambed for a distance equal to the anticipated depth of scour and weight with concrete blocks. As scour occurs,this section will drop into place.

3. Pile brush on the bank side of the fence and plant willow saplings on bank to encourage sediment deposits.

In the lower riparian zone (open floodway) bank stabilization efforts should be concentrated on critical areas only. The stabilizing effect of riprap can be supplemented with willows which will bind soil through their roots and screen the bank. Banks can be paved with stone (set in sand). Willow cuttings in joints need to be long enough to extend to natural soil and should have 2 to 4 buds above surface. Willow branches in riprap should be installed simultaneously. Branches should extend 1 foot into the soil below stone and 1 1/2 feet above ground, pointing downstream.

Willow branch mat revetment takes the following steps to install:

1. Grade slope to approximately 2:1 and excavate a 3 foot ditch at the toe of the slope.

2. Lay live willow brush with butts upslope and anchor mat in the ditch below normal waterline by packing with large stones.

3. Drive 3-foot willow stakes 2 1/2 feet on center to hold down brush; connect stakes

with No. 9 galvanized wire and cover brush slightly with dirt to encourage sprouting.

Maintenance

- Costs vary according to local availability of labor. However, there are practically no maintenance costs for vegetation once it is established, holding the banks 'naturally' as compared to concrete 'improvement' that constantly needs repairs.

All temporary and permanent erosion and sediment control practices shall be maintained and repaired as needed to assure continued performance of their intended function.

References

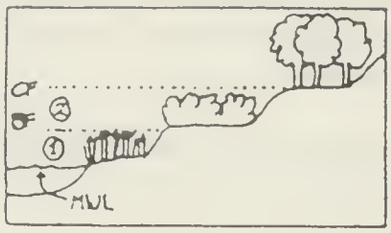
(1) U.S. Soil Conservation Service, Engineering Field Manual for Conservation Practices, 1969.

(2) U.S. Soil Conservation Service, Farm Planners Engineering Handbook for the Upper Mississippi Region, Agricultural Handbook #57, 1953.

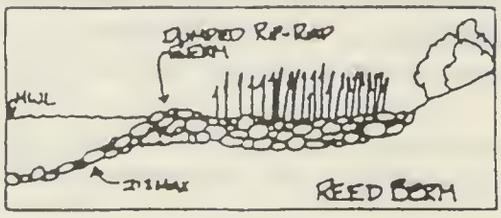
(3) Schiectl, Hugo, Bioengineering for Land Reclamation and Conservation, p. 404, University of Alberta Press, 1980.

(4) Gray, Donald H. and Leiser, A.T., Biotechnical Slope Protection and Erosion Control, p.271), Leiser Van Reinhold Inc., 1982.

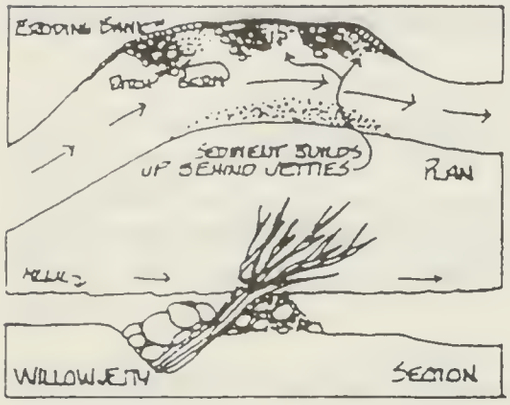
Figure 12 Streambank Stabilization



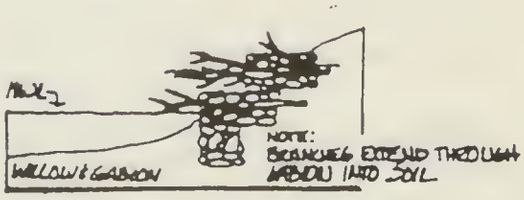
Reed Bank Zone (BF)
and Lower Riparian Zone (OF)



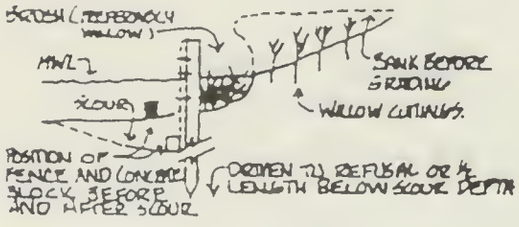
Reed Berm



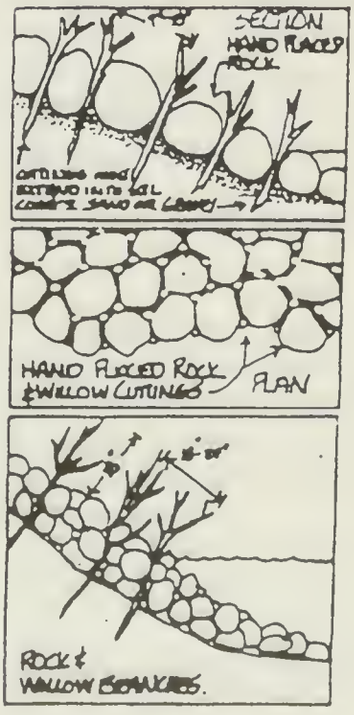
Willow Jetty



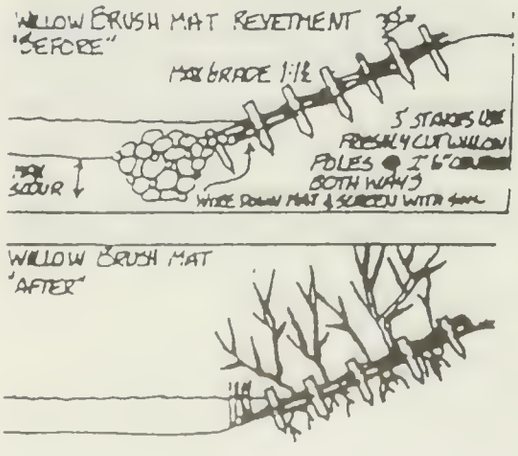
Willow Gabion



Piling Revetment



Willow Branches in Riprap



Willow Branch Mat Revetment

STRUCTURAL STREAMBANK STABILIZATION

Symbol:

Definition:

Methods of stabilizing the banks and streams with permanent structures.

Purpose:

To protect streambanks from the erosive forces of moving water, where vegetative or bioengineered methods are insufficient or infeasible.

Controlling off-site erosion. Properties and waterways downstream from development sites shall be protected from erosion due to increases in the volume, velocity and peak flow rate of stormwater runoff from the project site. While conducting land disturbing activities, limit the peak rate of runoff for the 2-year, 24-hour storm to 50 percent of the release rate for existing site conditions.

Stabilization of waterways and outlets. All temporary on-site conveyance channels shall be designed and constructed to withstand the expected velocity of flow from a 2-year, 24-hour frequency storm for the developed condition without erosion. Stabilization adequate to prevent erosion of outlets, adjacent streambanks, slopes and downstream reaches shall be provided at the outlets of all pipes and channels.

Conditions Where Practice Applies

- Streambank sections, where excessive erosion is anticipated because of highly erodible soils.

Advantages

1. Permanent structural measures are an effective method of preventing severe streambank erosion.

Disadvantages/Problems

1. Most types of structural stabilization do not offer any water quality benefits except for the potential for reduced erosion and downstream siltation.

Planning Considerations

Stream channel erosion problems vary widely in type and scale and there are many different structural stabilization techniques which have been employed with varying degrees of effectiveness. The purpose of this specification is merely to point out some of the practices which are available and to establish some broad guidelines for their selection and design. Such structures should be planned and designed in advance by a professional engineer licensed in the state of Montana. Many of the practices referenced here involve the use of manufactured products and should be designed and installed in accordance with manufacturer's specifications.

Before selecting a structural stabilization technique, the designer should carefully evaluate the possibility of using vegetative stabilization or bioeningeering measures to achieve the desired protection. Vegetative techniques are generally less costly and more compatible with natural stream characteristics.

Design Criteria

- Design must be prepared based on criteria and input/review from a qualified fisheries biologist.

- Since each reach of channel requiring protection is unique, measures for streambank protection shall be installed according to a plan and adapted to the specific site. Design shall be developed according to the following principles:

    1. Bottom scour shall be controlled, by either natural or structural means, before any permanent type of bank protection can be considered feasible.

    2. Stream requirements must be met.

    3. Special attention shall be given to maintaining and improving habitat for fish and wildlife.

    4. Structural measures must be effective for the design flow and be capable of withstanding greater flows without serious damage.

- The following structural streambank stabilization measures may be considered:

    1. Riprap - heavy angular stone placed on the streambank to provide armor protection against erosion.

    2. Gabion - rectangular, pervious, semi-flexible rock-filled wire baskets which can be used to armor streambanks.

    3. Reinforced Concrete - retaining walls or bulkhead used to armor eroding sections of streambank.

    4. Log Cribbing - retaining structure built of logs to protect streambanks from erosion. (Log crossings can have vegetation inserted between logs.)

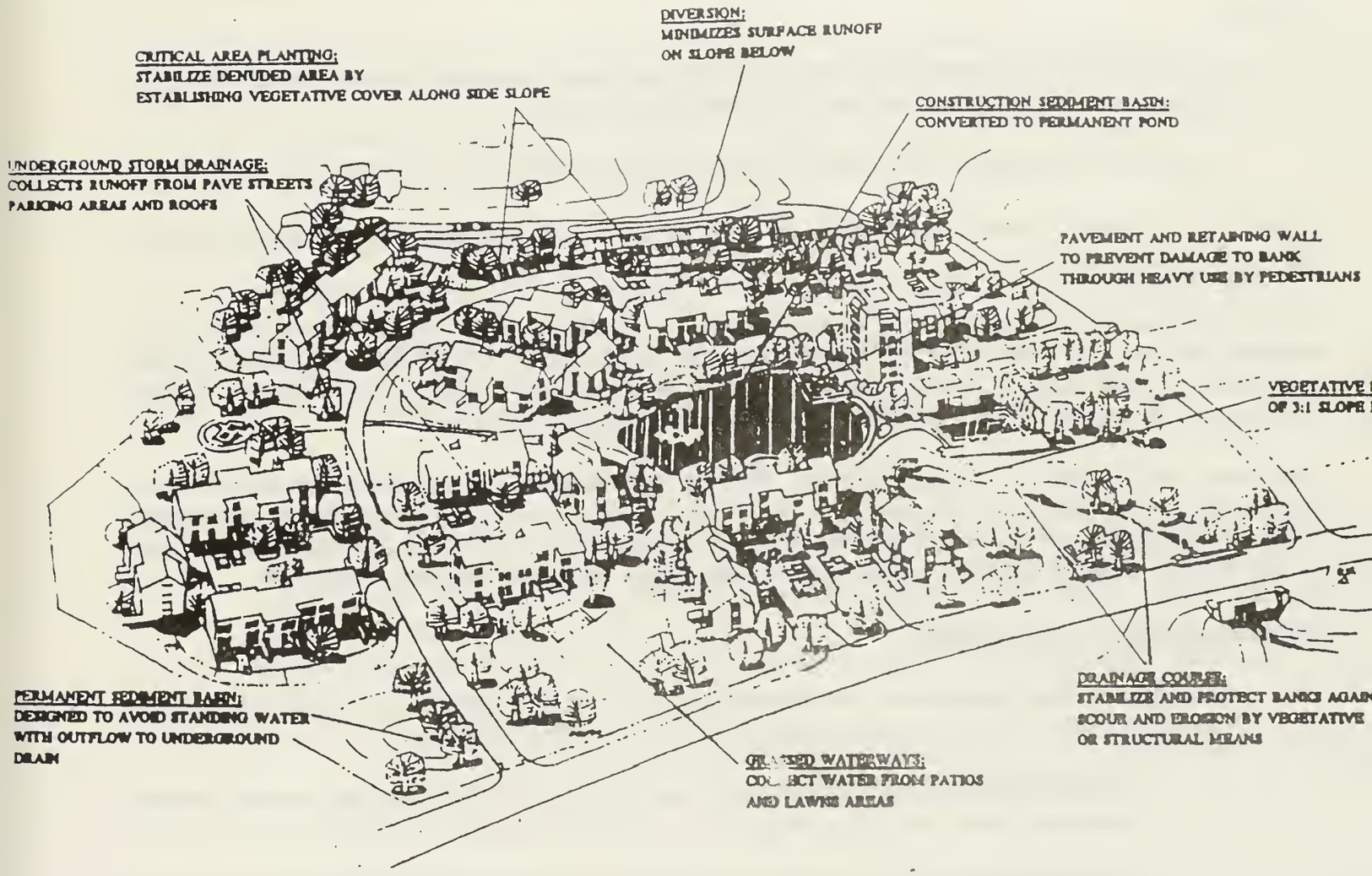
    5. Grid Pavers - modular concrete units with interspersed void areas which can be used to armor the streambank while maintaining porosity and allowing the establishment of vegetation.

Maintenance

- Inspections should be made regularly and after each large storm event. Repairs should be made as quickly as possible after the problem occurs.

All temporary and permanent erosion and sediment control practices shall be maintained and repaired as needed to assure continued performance of their intended function.

Many Temporary Measures can be Made Permanent



FILTER FENCE

Symbol: —x—x—x—x—

Definition:

A temporary sediment barrier consisting of a filter fabric stretched across and attached to supporting posts and entrenched. There are two types. The Silt Fence is a temporary linear filter barrier constructed of synthetic filter fabric, posts and, depending upon the strength of the fabric used, wire fence for support. The Filter Barrier is constructed of stakes and synthetic filter fabric.

Purpose:

1. To intercept and detain small amounts of sediment from disturbed areas during construction operations in order to prevent sediment from leaving the site.

2. To decrease the velocity of sheet flows and low-to-moderate level channel flows.

Protection of adjacent properties. Properties adjacent to the project site shall be protected from sediment deposition.

Timing and stabilization of sediment trapping measures. Sediment ponds and traps, perimeter dikes, sediment barriers, and other BMPs intended to trap sediment on-site must be constructed as a first step in grading. These BMPs must be functional before land disturbing activities take place. Earthen structures such as dams, dikes and diversions shall be seeded and mulched.

Controlling off-site erosion. Properties and waterways downstream from development sites shall be protected from erosion due to increases in the volume, velocity and peak flow rate of stormwater runoff from the project site. While conducting land disturbing activities, limit the peak rate of runoff for the 2-year, 24-hour storm to 50 percent of the release rate for existing site conditions.

Conditions Where Practice Applies

- Filter fences must be provided just upstream of the point(s) of discharge of runoff from a site, before the flow becomes concentrated. They may also be required:

    1. Below disturbed areas where runoff may occur in the form of sheet and rill erosion; wherever runoff has the potential to impact downstream resources.

    2. Perpendicular to minor swales or ditch lines for up to one acre contributing drainage areas (in special cases).

- Filter fences should not be constructed in streams or large drainage channels.

- Synthetic fabric filter fences are applicable to only sheet or overland flows and cannot filter the volumes of water in concentrated flows.

Advantages

1. Downstream riparian properties will not be damaged by sediment deposits originating from the

development.

2. Sediment will not cause damage to fish habitat.

Disadvantages/Problems

1. Filter fences are not practical where large flows of water are involved, hence the need to restrict their use to drainage areas of one acre or less and flow rates of less than 0.5 dfs and only used for special circumstances.

2. Problems may arise from incorrect selection of pore size and/or improper installation.

Planning Considerations

Laboratory work at the Virginia Highway and Transportation Research Council has shown that silt fences can trap a much high percentage of suspended sediments than can straw bales. Silt fences are preferable to straw barriers in many cases. However, while the failure rate of silt fences is lower than that of straw barriers, there are many instances locally in which silt fences have been improperly installed. The installation methods outlined here can improve performance.

Design Criteria

- Drainage area of 1 acre or less or in combination with sediment basin in a larger site.
- Maximum slope steepness (normal (perpendicular) to fence line) 1:1.
- Maximum sheet or overland flow path length to the fence 100 feet.
- No concentrated flows greater than 0.5 cfs.
- Selection of a filter fabric is based on soil conditions at the construction site (which affect the equivalent opening size (EOS) fabric specification) and characteristics of the support fence (which affect the choice of tensile strength). The designer shall specify a filter fabric th retains the soil found on the construction site yet will have openings large enough to permit drainage and prevent clogging. The following criteria is recommended for selection of the equivalent opening size:

  1. If 50 percent or less of the soil, by weight, will pass the U.S. standard sieve No. 200, select the EOS to retain 85 percent of the soil. The EOS should not be finer than EOS 70.

  2. For all other soil types, the EOS should be no larger than the openings in the U.S. Standard Sieve No. 70 [0.0083 in. (0.21 mm)] except where direct discharge to a stream, lake or wetland will occur, then the EOS shall be no larger than Standard Sieve No. 100.

  To reduce the chance of clogging, it is preferable to specify a fabric with openings as large as allowed by the criteria. No fabric should be specified with an EOS smaller than U.S. Standard Sieve No. 100 [0.0059 in. (0.14 mm)]. If 85 percent or more of a soil, by weight, passes through the openings in a No. 200 sieve [0.0029 in (0.074 mm)], filter fabric shall not be used. Most of the particles in such a soil would not be retained if the EOS was too large, and they would clog the fabric quickly if the EOS was small enough to capture the soil.

Selection of fabric tensile strength and bursting strength characteristics shall be supported with wire mesh in and as recommended by the fabric manufacturer. Filter fabric material shall contain ultraviolet ray inhibitors and stabilizers to provide a minimum os six months of expected usable construction life at a temperature range of 0°F to 120°F.

Standard Notes

In addition to the Technical Information Report required by the local government when preparing an erosion and sediment control plan, add the following notes to the Filter Fabric Fence Detail:

1. The filter fabric shall be purchased in a continuous roll cut to the length of the barrier to avoid use of joints. When joints are necessary, filter cloth shall be spliced together only at a support post, with a minimum 6 inch overlap, and both ends securely fastened to the post.

2. Posts shall be spaced a maximum of 6 feet apart and driven securely into the ground a minimum of 30 inches (where physically possible).

3. A trench shall be excavated approximately 8 inches wide and 12 inches deep along the line of posts and upslope from the barrier. The trench shall be constructed to follow the contour.

4. When standard strength filter fabric is used, a wire mesh support fence shall be fastened securely to the upslope side of the posts using heavy-duty wire staples at least 1 inch long, tie wires or hog rings. The wire shall extend into the trench a minimum of 4 inches and shall not extend more than 36 inches above the original ground surface.

5. The standard strength filter fabric shall be stapled or wired to the fence and 20 inches of the fabric shall extend into the trench. The fabric shall not extend more than 36 inches above the original ground surface. Filter fabric shall not be stapled to existing trees.

6. When extra-strength filter fabric and closer post spacing are used, the wire mesh support fence may be eliminated. In such a case, the filter fabric is stapled or wired directly to the posts with all other provisions of Standard Note "e" applying.

7. The trench shall be backfilled with 1/4 inch minimum diameter washed gravel. Local governments may instead specify the use of properly compacted native material.

8. Filter fabric fences shall be removed when they have served their useful purpose, but not before the upslope area has been permanently stabilized.

Maintenance

- Inspect immediately after each rainfall and at least daily during prolonged rainfall. Repair as necessary.

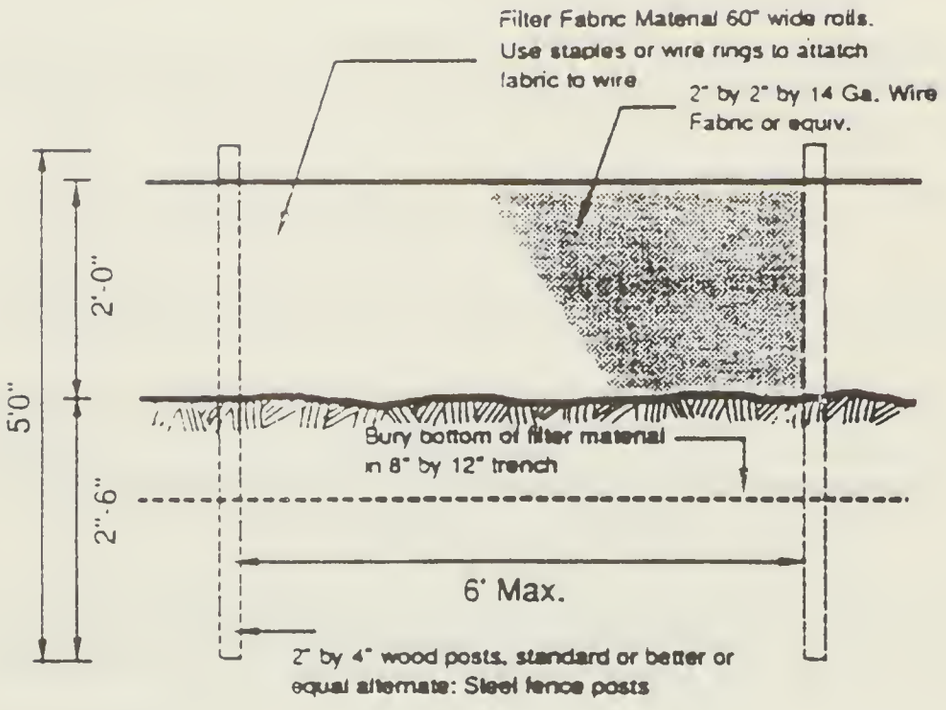
- Sediment must be removed when it reaches approximately one third the height of the fence, especially if heavy rains are expected.

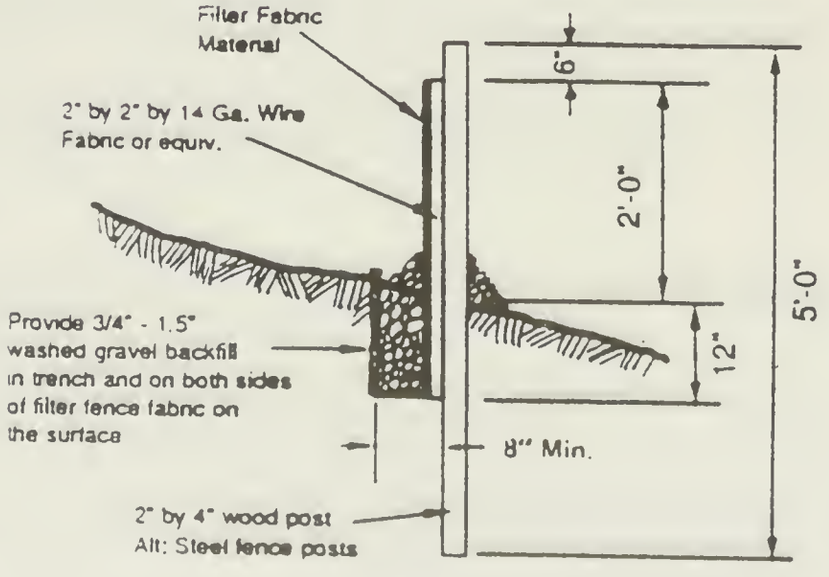
- Any sediment deposits remaining in place after the filter fence is no longer required shall be dressed to conform with the existing grade, prepared and seeded.

Removal of temporary measures. All temporary erosion and sediment control measures shall be removed with 30 days after final site stabilization is achieved or after the temporary BMPs are no

longer needed. Trapped sediment shall be removed or stabilized on-site. Disturbed soil areas resulting from removal shall be permanently stabilized.

Figure 13 Filter Fabric Fence Detail


Filter Fabric Material 60" wide rolls.
Use staples or wire rings to attatch fabric to wire
2" by 2" by 14 Ga. Wire Fabric or equiv.
5'0"
2'-0"
2'-6"
Bury bottom of filter material in 8" by 12" trench
6' Max.
2" by 4" wood posts, standard or better or equal alternate: Steel fence posts


Filter Fabric Material
2" by 2" by 14 Ga. Wire Fabric or equiv.
6"
2'-0"
5'-0"
12"
Provide 3/4" - 1.5" washed gravel backfill in trench and on both sides of filter fence fabric on the surface
8" Min.
2" by 4" wood post
Alt: Steel fence posts

STRAW BALE BARRIER

Symbol:

Definition:

A temporary sediment barrier consisting of a row of entrenched and anchored straw bales.

Purpose:

1. To intercept and detain small amounts of sediment from disturbed areas of limited extent to prevent sediment from leaving the site.

2. To decrease the velocity of sheet flows and low-to-moderate level channel flows.

Protection of adjacent properties. Properties adjacent to the project site shall be protected from sediment deposition.

Timing and stabilization of sediment trapping measures. Sediment ponds and traps, perimeter dikes, sediment barriers, and other BMPs intended to trap sediment on-site must be constructed as a first step in grading. These BMPs must be functional before land disturbing activities take place. Earthen structures such as dams, dikes and diversions shall be seeded and mulched.

Controlling off-site erosion. Properties and waterways downstream from development sites shall be protected from erosion due to increases in the volume, velocity and peak flow rate of stormwater runoff from the project site. While conducting land disturbing activities, limit the peak rate of runoff for the 2-year, 24-hour storm to 50 percent of the release rate for existing site conditions.

Conditions Where Practice Applies

- Below disturbed areas subject to sheet and rill erosion.
- Where the size of the drainage area is no greater than 1/4 acre per 100 feet of barrier length; the maximum slope length behind the barrier is 100 feet' and the maximum slope gradient behind the barrier is 50 percent (2:1).
- In minor swales or ditch lines where the maximum contributing drainage area is no greater than 2 acres.
- Where effectiveness is required for less than 3 months.
- Under no circumstances should straw bale barriers be constructed in live streams, swales or drainages.

Advantages

1. When properly used, straw bale barriers are an inexpensive method of sediment control.

Disadvantages/Problems

1. Straw bale barriers are easy to misuse and can become contributors to a sediment problem instead of a solution.

2. It is difficult to tell if bales are securely seated and snug against each other.

Planning Considerations

Based on observations made locally and in Virginia, Pennsylvania, Maryland and other parts of the nation, straw bale barriers have not been as effective as many users had hoped they would be. There are three major reasons for such ineffectiveness.

1. *Improper use of straw bale barriers has been a major problem. Straw bale barriers have been used in streams and drainageways where high water velocities and volumes have destroyed or impaired their effectiveness.*

2. *Improper placement and installation of the barriers, such as staking the bales directly to the ground with no soil seal or entrenchment, has allowed undercutting and end flow. This has resulted in additions to rather than removal of sediment from runoff waters.*

3. *Inadequate maintenance lowers the effectiveness of these barriers. For example, trapping efficiencies of carefully installed straw bale barriers on one project in Virginia dropped from 57 percent to 16 percent in one month due to lack of maintenance.*

There are serious questions about the continued use of straw bale barriers as they are presently installed and maintained. Averaging approximately $4.00 per linear foot, the thousands of straw bale barriers used annually represent sufficient expense that optimum installation procedures should be emphasized. If such procedures are carefully followed, straw bale barriers can be quite effective. Therefore, continued designation of straw bale barriers as a BMP will be contingent upon significant improvement in the installation and maintenance procedures applied to their use.

Design Criteria

- A formal design is not required.

- Sheet Flow Applications

  1. Bales shall be placed in a single row, lengthwise on the contour, with ends of adjacent bales tightly abutting one another.

  2. All bales shall be either wire-bound or string-tied. Straw bales shall be installed so that the bindings are oriented around the sides rather than along the topes and bottoms of the bales in order to prevent deterioration of the bindings.

  3. The barrier shall be entrenched and backfilled. A trench shall be excavated the width of a bale and the length of the proposed barrier to a minimum depth of 4 inches. The trench must be deep enough to remove all grass and other material which might allow underflow. After the bales are staked and chinked (filled by wedging), the excavated soil shall be backfilled against the barrier. Backfill soil shall conform to the ground level on the downhill side and shall be built up to 4 inches against the uphill side of the barrier.

  4. Each bale shall be securely anchored by at least 2 stakes or re-bars driven through the bale. The first stake in each bale shall be driven toward the previously laid bale to force the bales together. Stakes or re-bars shall be driven deep enough into the ground to securely anchor the bales. Stakes should not extend above the bales but instead

should be driven in flush with the tope of the bale for safety reasons.

5. The gaps between the bales shall be chinked (filled by wedging) with straw to prevent water from escaping between the bales. Loose straw scattered over the area immediately uphill from a straw bale barrier tends to increase barrier efficiency. Wedging must be done carefully in order not to separate the bales.

Cross Section of a Properly Installed Straw Bale Barrier

6. Inspection shall be frequent and repair or replacement shall be made promptly as needed.

7. Straw bale barriers shall be removed when they have served their usefulness, but not before the upslope areas have been permanently stabilized.

- Channel Flow Applications

1. Bales shall be placed in a single row, lengthwise, oriented perpendicular to the contour, with ends of adjacent bales tightly abutting one another.

2. The remaining steps for installing a straw bale barrier for sheet flow applications apply here, with the following addition:

3. The barrier shall be extended to such a length that the bottoms of the end bales are higher in elevation that the top of the lowest middle bales to assure that sediment-laden runoff will flow either through or over the barrier but not around it.

Maintenance

- Straw bale barriers shall be inspected immediately after each runoff-producing rainfall and at least daily during prolonged rainfall.

- Close attention shall be paid to the repair of damaged bales, end runs and undercutting beneath bales.

- Necessary repairs to barriers or replacement of bales shall be accomplished promptly.

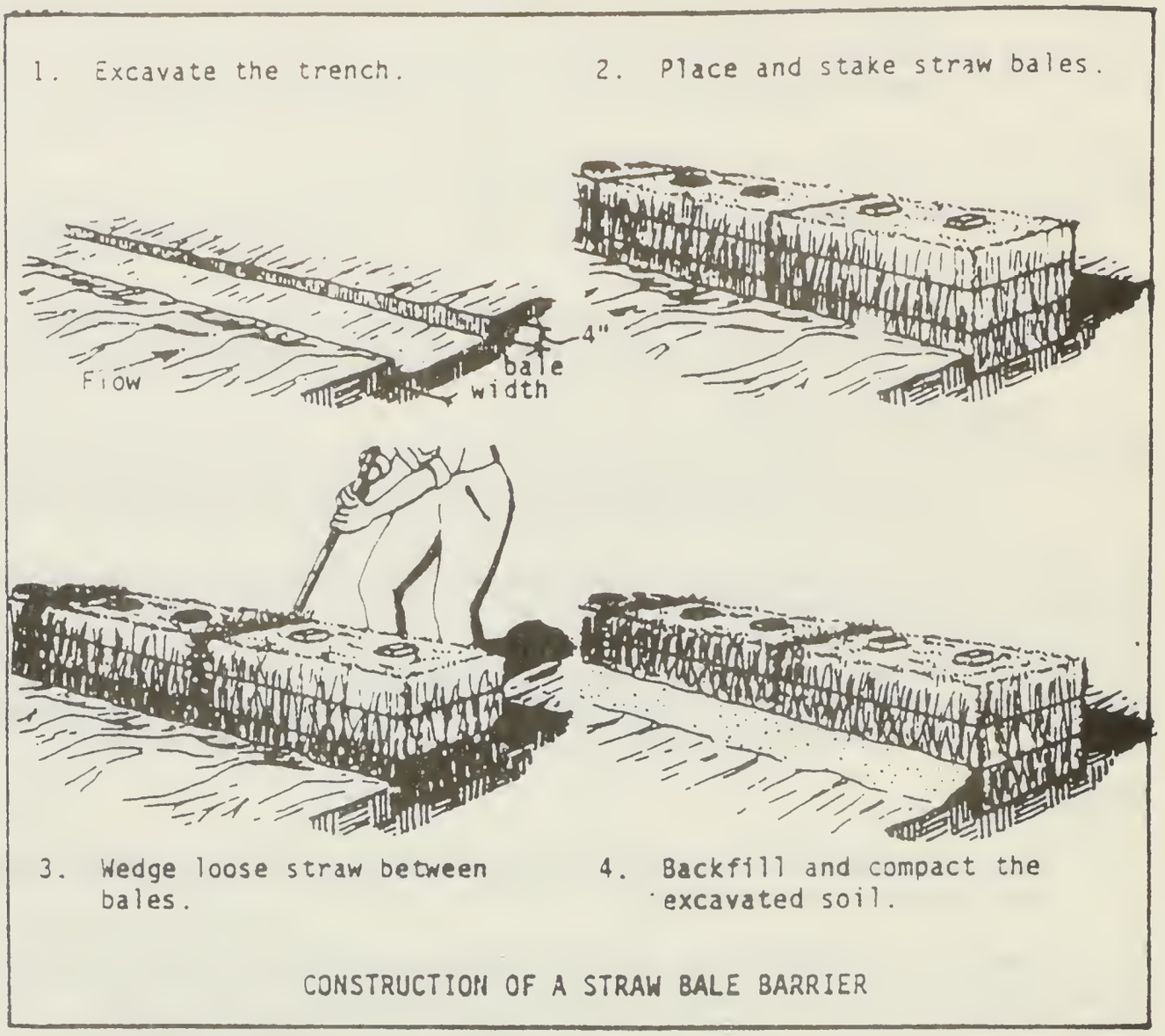
- Sediment deposits should be removed after each runoff-producing rainfall. They must be removed when the level of deposition reaches approximately one-half the height of the barrier.

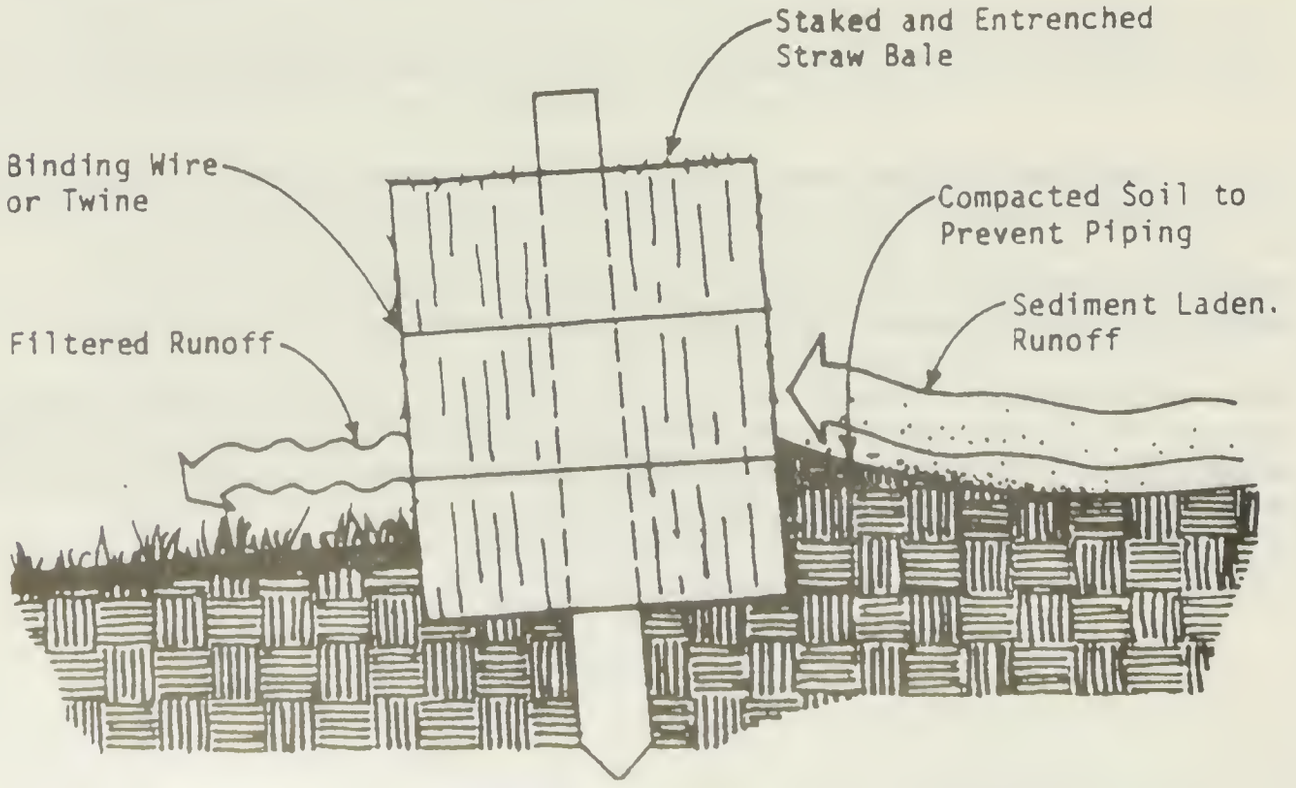
- Any sediment deposits remaining in place after the straw bale barrier is no longer required shall be dressed to conform to the existing grade, prepared and seeded.

All temporary and permanent erosion and sediment control practices shall be maintained and repaired as needed to assure continued performance of their intended function.

Removal of temporary measures. All temporary erosion and sediment control measures shall be removed with 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil areas resulting from removal shall be permanently stabilized.

Figure 14 STRAW BALE BARRIER


1. Excavate the trench.
2. Place and stake straw bales.
Flow
bale width
4"
3. Wedge loose straw between bales.
4. Backfill and compact the excavated soil.
CONSTRUCTION OF A STRAW BALE BARRIER



BRUSH BARRIER

Symbol:

Definition:

A temporary sediment barrier constructed at the perimeter of a disturbed area from the residue materials available from cleaning and grubbing the site.

Purpose:

To intercept and retain sediment from limited disturbed areas.

Protection of adjacent properties. Properties adjacent to the project site shall be protected from sediment deposition.

Timing and stabilization of sediment trapping measures. Sediment ponds and traps, perimeter dikes, sediment barriers, and other BMPs intended to trap sediment on-site must be constructed as a first step in grading. These BMPs must be functional before land disturbing activities take place. Earthen structures such as dams, dikes and diversions shall be seeded and mulched.

Controlling off-site erosion. Properties and waterways downstream from development sites shall be protected from erosion due to increases in the volume, velocity and peak flow rate of stormwater runoff from the project site. While conducting land disturbing activities, limit the peak rate of runoff for the 2-year, 24-hour storm to 50 percent of the release rate for existing site conditions.

Conditions Where Practice Applies

- Below disturbed areas of less than one quarter acre that are subject to sheet and rill erosion, where enough residue material is available for construction of such a barrier. Note: This does not replace a sediment trap or pond.

Advantages

1. Brush barriers can often be constructed using materials found on-site.

Disadvantages/Problems

1. None

Planning Considerations

Organic litter and spoil material from site clearing operations is usually burned or hauled away to be dumped elsewhere. Much of this material can be used effectively on the construction site itself. During clearing and grubbing operations, equipment can push or dump the mixture of limbs, small vegetation, and root mat along with minor amounts of soil and rock into windrows along the toe of a slope where erosion and accelerated runoff are expected. Anchoring a filter fabric over the berm enhances the filtration ability of the barrier. Because brush barriers are fairly stable and composed of natural materials, maintenance requirements are small.

Design Criteria

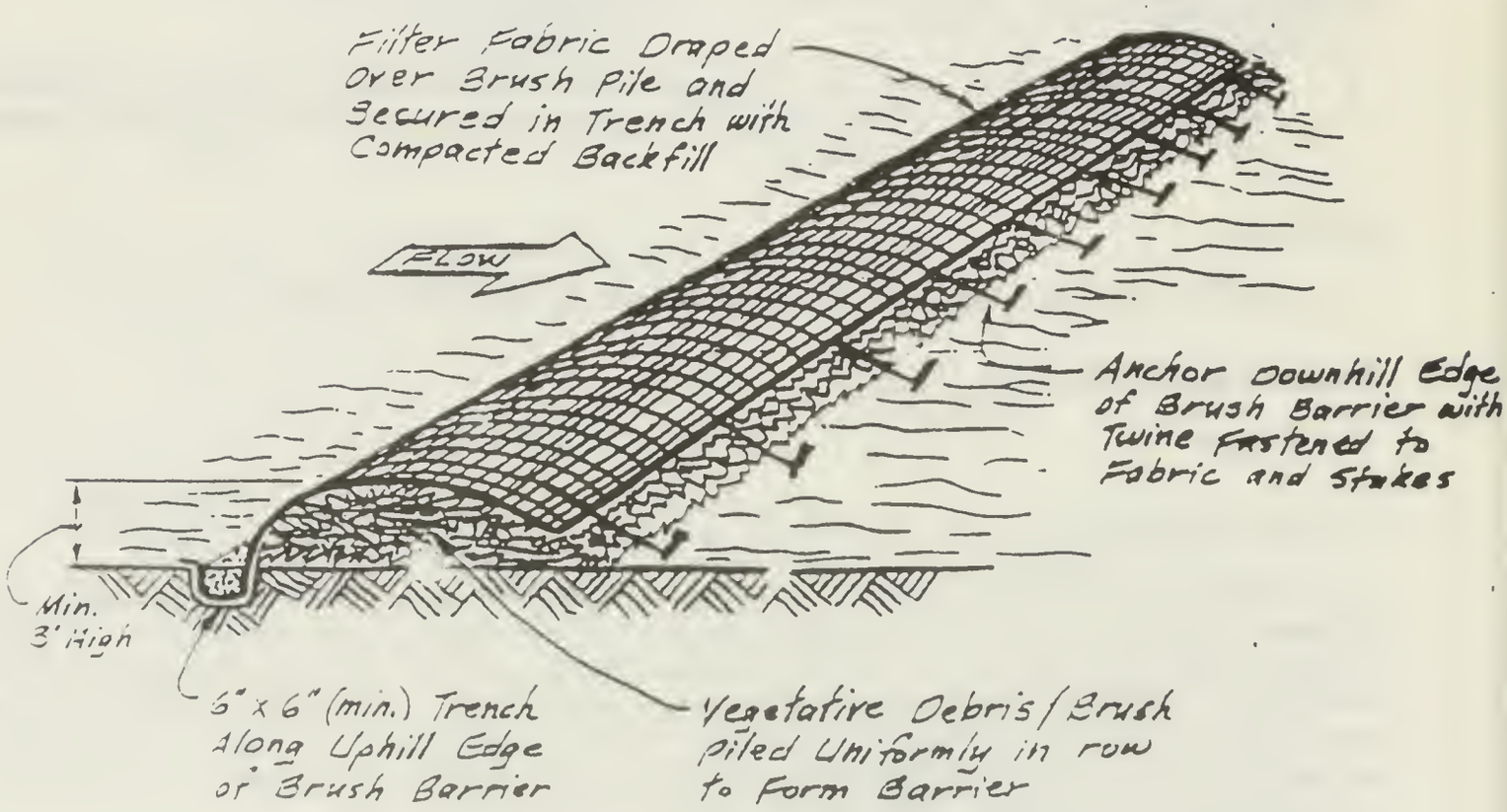
- Height 3 feet (minimum) to 5 feet (maximum).
- Width 5 feet at base (minimum) to 14 feet (maximum).
- A filter fence anchored over the berm will enhance its filtration capacity.
- Further design details are illustrated in Figure 15.

Maintenance

- Brush barriers generally require little maintenance, unless there are very heavy deposits of sediment. Occasionally, tearing of the fabric may occur.
- When the barrier is no longer needed the fabric can be removed to allow natural establishment of vegetation within the barrier. Over time the barrier will rot.

All temporary and permanent erosion and sediment control practices shall be maintained and repaired as needed to assure continued performance of their intended function.

Figure 15 Brush Barrier


Filter Fabric Draped over Brush Pile and Secured in Trench with Compacted Backfill
FLOW
Anchor Downhill Edge of Brush Barrier with Twine Fastened to Fabric and Stakes
Min. 3' High
6" x 6" (min.) Trench Along Uphill Edge of Brush Barrier
Vegetative Debris/Brush piled Uniformly in row to Form Barrier

GRAVEL FILTER BERM

Symbol: GFB

Definition:

A gravel berm constructed on right-of-ways or traffic areas within a construction site.

Purpose:

To retain sediment from traffic areas by using a filter berm of gravel or crushed rock.

Protection of adjacent properties. Properties adjacent to the project site shall be protected from sediment deposition.

Timing and stabilization of sediment trapping measures. Sediment ponds and traps, perimeter dikes,sediment barriers, and other BMPs intended to trap sediment on-site must be constructed as a first step in grading. These BMPs must be functional before land disturbing activities take place. Earthen structures such as dams, dikes and diversions shall be seeded and mulched.

Controlling off-site erosion. Properties and waterways downstream from development sites shall be protected from erosion due to increases in the volume, velocity and peak flow rate of stormwater runoff from the project site. While conducting land disturbing activities, limit the peak rate of runoff for the 2-year, 24-hour storm to 50 percent of the release rate for existing site conditions.

Conditions Where Practice Applies

- Where a temporary measure is needed to retain sediment from right-of-ways or in traffic areas on construction sites.

Advantages

1. This is a very efficient method of sediment removal.

Disadvantages/Problems

1. This BMP is more expensive to install than are other BMPs which use materials found on-site.

Design Criteria

- Berm material shall be 1/4 to 3 inches in size, washed,well-graded gravel or crushed rock with less than 5 percent fines.

- Spacing of berms:

  Every 300 feet on slopes less than 5 percent
  Every 200 feet on slopes between 5 and 10 percent
  Every 100 feet on slopes more than 10 percent

- Berm dimensions:

  1 foot high with 3:1 side slopes

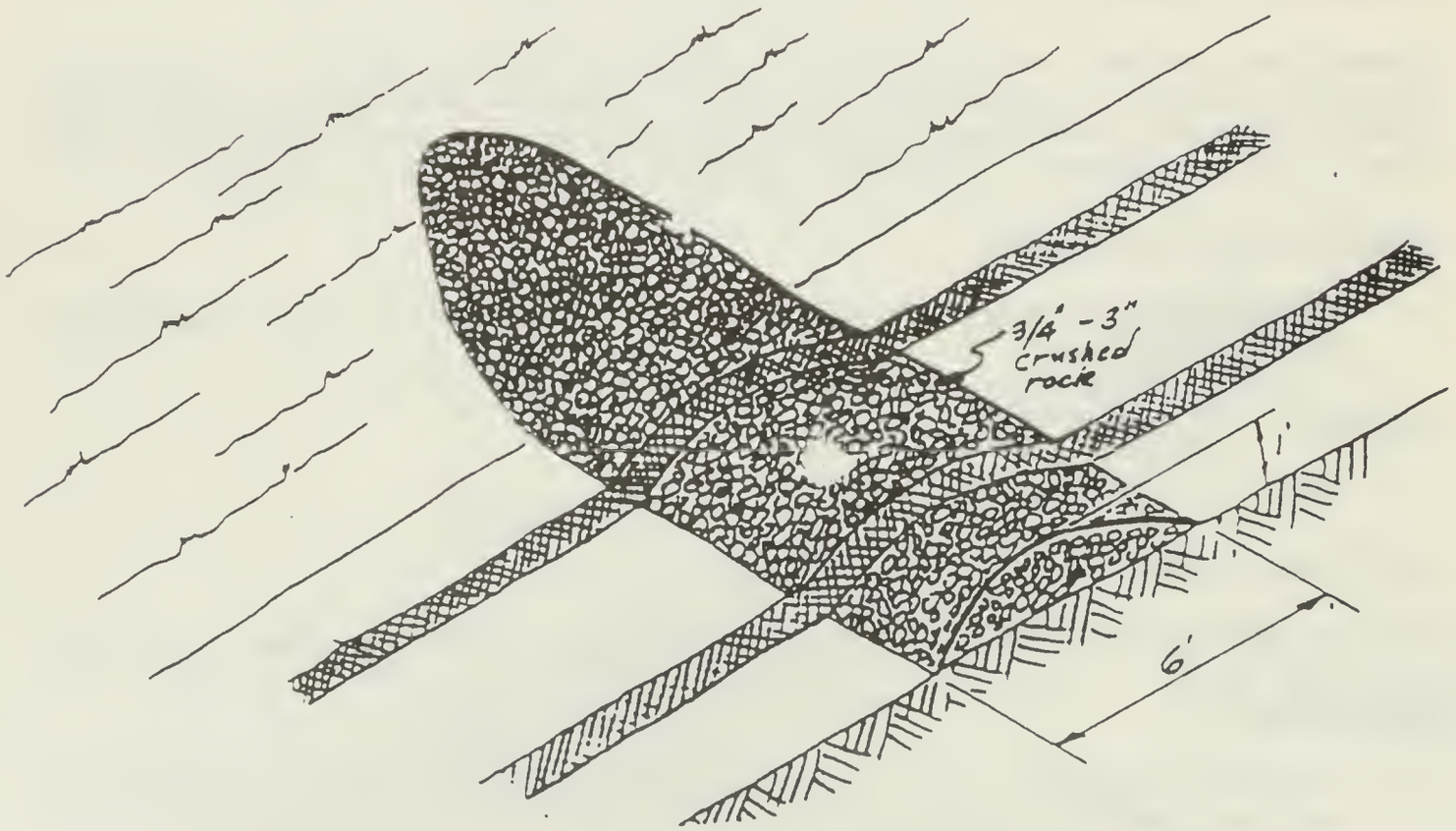
8 linear feet per 1 cfs runoff based on the 10-year, 24-hour design storm.

Maintenance

- Regular inspection is required; sediment shall be removed and filter material replaced as needed.

All temporary and permanent erosion and sediment control practices shall be maintained and repaired as needed to assure continued performance of their intended function.

Figure 16 Gravel Filter Berm



STORM DRAIN INLET PROTECTION

Symbol:

Definition:

A sediment filter or an excavated impounding area around a storm drain, drop inlet or curb inlet.

Purpose:

To prevent sediment from entering storm drainage systems prior to permanent stabilization of the disturbed area.

Storm drain inlet protection.

Timing and stabilization of sediment trapping measures. Sediment ponds and traps, perimeter dikes,sediment barriers, and other BMPs intended to trap sediment on-site must be constructed as a first step in grading. These BMPs must be functional before land disturbing activities take place. Earthen structures such as dams, dikes and diversions shall be seeded and mulched.

Conditions Where Practice Applies

- Where storm drain inlets are to be made operational before permanent stabilization of the disturbed drainage area. Difference types of structures are applicable to different conditions:

    1. Filter Fabric Fence - applicable where the inlet drains a relatively small (less than 1 acre) flat area (less than 5 percent slope) (see Figure 17). Do not place fabric under grate as the collected sediment may fall into the drain when the fabric is retrieved.

    2. Block and Gravel Filter - applicable where heavy flows (greater than 0.5 cfs) are expected (Figure 18).

    3. Gravel and Wire Mesh Filter - applicable where flows greater than 0.5 cfs are expected and construction traffic may occur over the inlet (Figure 18).

Advantages

1. Inlet protection prevents sediment from entering the storm drain system and clogging it.

Disadvantages/Problems

1. None

Planning Considerations

Storm sewers which are made operational before their drainage area is stabilized can convey large amounts of sediment to natural drainageways. In cases of extreme sediment loading, the storm sewer itself may clog and lose a major portion of its capacity. To avoid these problems, it is necessary to prevent sediment rom entering the system at the inlets.

This practice contains several types of inlet filters and traps which have different applications dependent upon site conditions and type of inlet. Other innovative techniques for accomplishing the

same purpose are encouraged, but only after specific plans and details are submitted to and approved by the Plan Approving Authority of the local government.

Note that these various inlet protection devices are for drainage areas of less than one acres. Runoff from larger disturbed areas should be routed through a Temporary Sediment Trap or Pond.

The best way to prevent sediment from entering the storm sewer system is to stabilize the site as quickly as possible, preventing erosion and stopping sediment at its source.

Design Criteria

- Grates and spaces of all inlets should be secured to prevent seepage of sediment-laden water.
- All inlet protection measures should include sediment sumps of 1 to 2 feet in depth and with 2:1 side slopes (Figure 17).
- Installation procedure for filter fabric fence:

    1. Place 2 inch by 2 inch wood stakes around the perimeter of the inlet a maximum of 3 feet apart and drive them at least 8 inches into the ground. The stakes must be at least 3 feet long.

    2. Excavate a trench approximately 8 inches wide and 12 inches deep around the outside perimeter of the stakes.

    3. Staple the filter fabric (for materials and specifications, see BMP E3.10, Filter Fence) to wooden stakes so that 32 inches of the fabric extends out and can be formed into the trench. Use heavy-duty wire staples at least 1/2 inch in length.

    4. Backfill the trench with 3/4 inch or less washed gravel all the way around.

- Installation procedure for block and gravel filter:

    1. Place wire mesh over the drop inlet so that the wire extends a minimum of 1 foot beyond each side of the inlet structure. Use hardware cloth or comparable wire mesh with one-half inch openings. If more than one strip is necessary, overlap the strips. Place filter fabric over the wire mesh.

    2. Place concrete block lengthwise on their sides in a single row around the perimeter of the inlet, so that the open ends face outward, not upward. The ends of adjacent blocks should abut. The height of the barrier can be varied, depending on design needs, by stacking combinations of blocks that are 4 inches, 8 inches, and 12 inches wide. The row of blocks should be at least 12 inches but no greater than 24 inches high (Figure 18).

    3. Place wire mesh over the outside vertical face (open end) of the concrete blocks to prevent stone from being washed through the blocks. Use hardware cloth or comparable wire mesh with one-half inch openings.

    4. Pile washed stone against the wire mesh to the top of the blocks. Use 3/4 to 3 inch gravel.

- Installation procedure for gravel and wire mesh filter:
  1. Place wire mesh over the drop inlet so that the wire extends a minimum of 1 foot beyond each side of the inlet structure. Use hardware cloth or comparable wire mesh with 1/2 inch opening. If more than one strip of mesh is necessary, overlap the strips. Place filter fabric over wire mesh.

  2. Extend the filter fence/wire mesh beyond the inlet opening at least 18 inches on all sides. Place 3/4 to 3-inch gravel over the filter fabric/wire mesh. The depth of the gravel should be at least 12 inches over the entire inlet opening (see Figure 18).

Maintenance

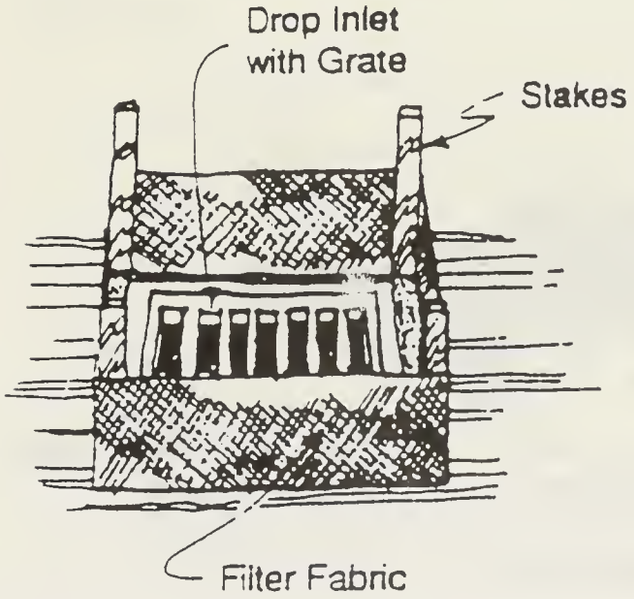
- For systems using filter fabric: inspections should be made on a regular basis, especially after large storm events. If the fabric becomes clogged, it should be replaced. Sediment should be removed when it reaches approximately one-half the height of the fence. If a sump is used, sediment should be removed when it fills approximately one-half the depth of the hole.

- For systems using stone filters: If the stone filter becomes clogged with sediment, the stones must be pulled away from the inlet and cleaned or replaced. Since cleaning of gravel at a construction site may be difficult, an alternative approach would be to use the clogged stone as fill and put fresh stone around the inlet.

All temporary and permanent erosion and sediment control practices shall be maintained and repaired as needed to assure continued performance of their intended function.

Removal of temporary measures. All temporary erosion and sediment control measures shall be removed with 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil areas resulting from removal shall be permanently stabilized.

Figure 17 Filter Fabric Fence Inlet Filter



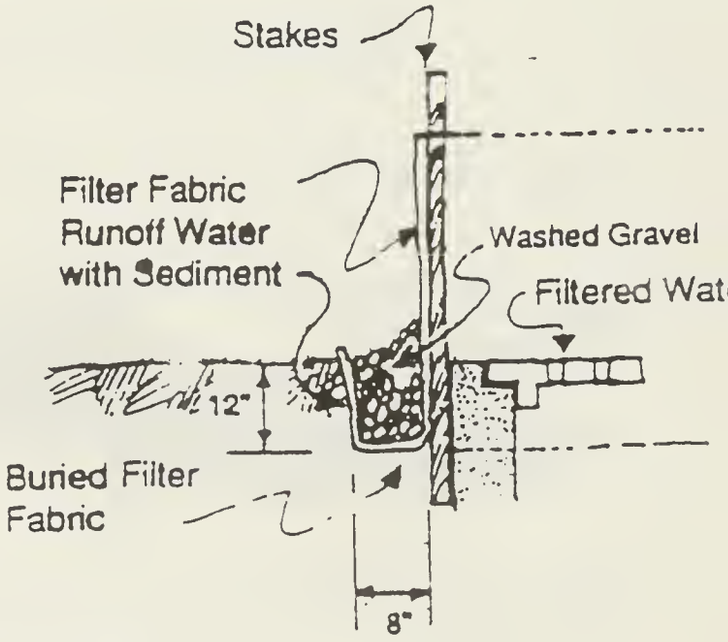
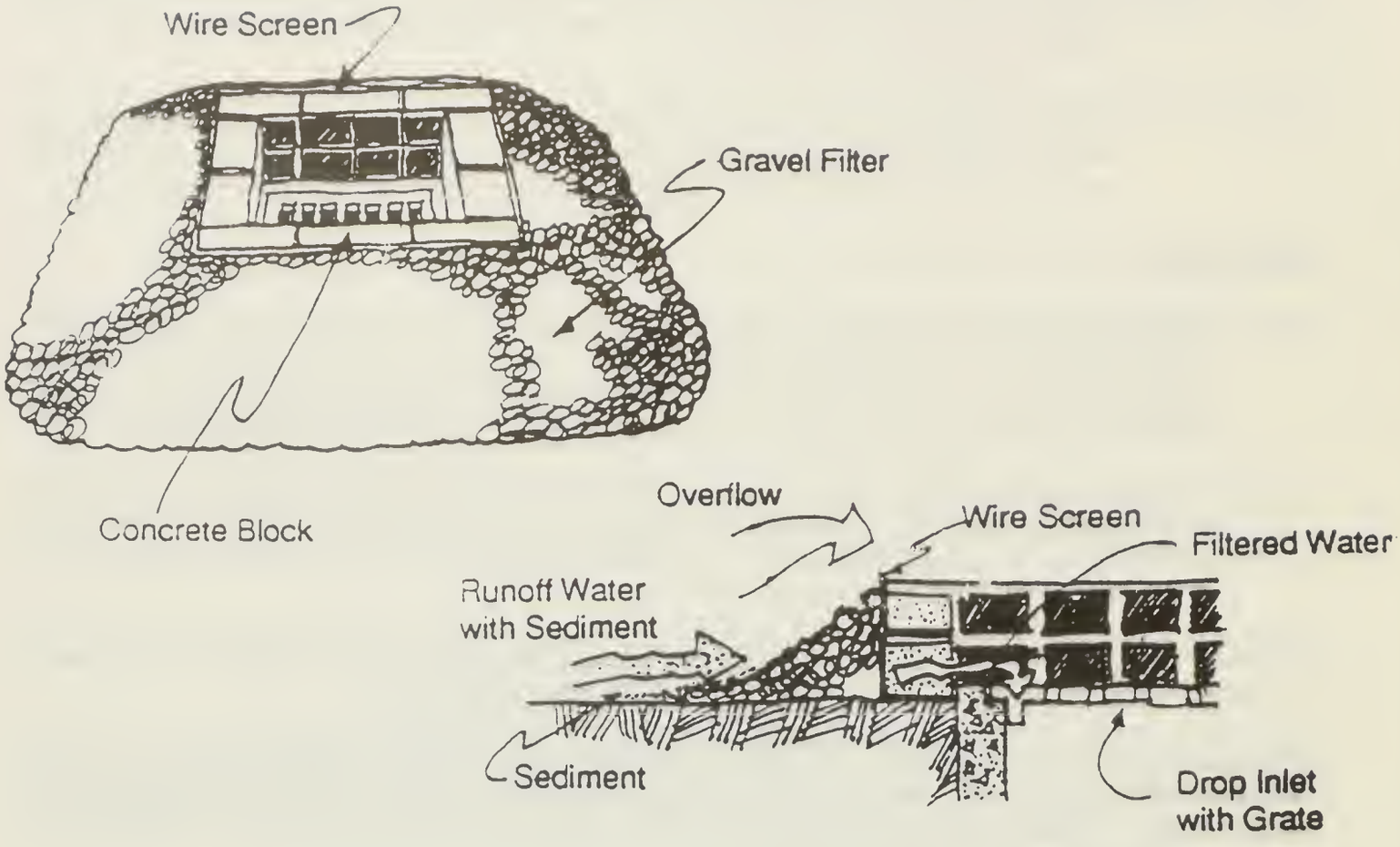
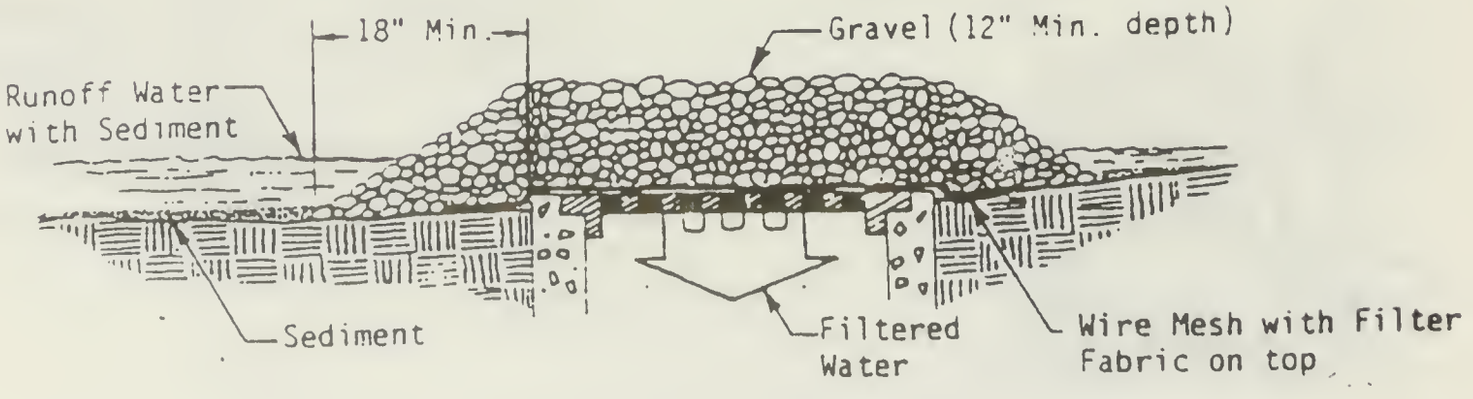


Figure 18 Block and Gravel Filter





Gravel and Wire Mesh Filter

SEDIMENT TRAP

Symbol:

Definition:

A small temporary ponding area, with a gravel outlet, formed by excavation and/or by constructing an earthen embankment.

Purpose:

To collect and store sediment from sites cleared and/or graded during construction. It is intended for use on relatively small building areas, with no unusual drainage features and projected quick build-out time. It should help in reducing silt-laden runoff. This silt-laden runoff clogs off-site conveyance systems and destroys habitat, particularly in streams. The trap is a temporary measure (with a design life of approximately 6 months) and is to be maintained until the site area is permanently protected against erosion by vegetation and/or structures.

Protection of adjacent properties. Properties adjacent to the project site shall be protected from sediment deposition.

Timing and stabilization of sediment trapping measures. Sediment ponds and traps, perimeter dikes,sediment barriers, and other BMPs intended to trap sediment on-site must be constructed as a first step in grading. These BMPs must be functional before land disturbing activities take place. Earthen structures such as dams, dikes and diversions shall be seeded and mulched.

Controlling off-site erosion. Properties and waterways downstream from development sites shall be protected from erosion due to increases in the volume, velocity and peak flow rate of stormwater runoff from the project site. While conducting land disturbing activities, limit the peak rate of runoff for the 5-year, 24-hour storm to 50 percent of the release rate for existing site conditions.

Conditions Where Practice Applies

- Proposed building sites where the tributary drainage area is less than 3 acres.

Advantages

1. Downstream riparian properties will not be damaged by sediment deposits originating from that development.

2. Sediment deposits downstream will not reduce the capacity of the stream channel.

3. Sediment will not cause the clogging of downstream impoundments and other facilities.

Disadvantages/Problems

1. Serves only limited areas.

2. Sediment traps (and ponds) are only practically effective in removing sediment down to about the medium silt size fraction. Runoff with sediment of finer grades (fine silt and clay) will pass through untreated, emphasizing the need to control erosion to the maximum extent first.

Planning Considerations

Sediment traps should be used only for small drainage areas. If the contributing drainage area is greater than 3 acres, refer to Sediment Ponds or subdivide the catchment area (see Figure 22).

Sediment must be periodically removed from the trap. Plans shall detail how this sediment is to be disposed of, such as by use in fill areas on-site or removal to an approved off-site dump. Sediment traps, along with other perimeter controls, shall be installed before any land disturbance takes place in the drainage area.

Safety

See Sediment Ponds.

Design Criteria

The sediment trap may be formed completely by excavation or by construction of a compacted embankment. It shall have a 1.5 foot deep sump for sediment storage. The outlet shall be a weir/spillway section, with the area below the weir acting as a filter for sediment and the upper area as the overflow spillway depth.

- See Figures 19 and 20 for details.
- The temporary sediment trap volume can be found by computing the detention volume required for the 5-year, 24-hour design storm using approved methods or good engineering practices. Side slopes should not exceed 3:1. After determining the necessary volume, size the trap by adding an additional 1 1/2 feet for sediment accumulation to the volume computed using the 5-year, 24-hour design storm.
- To complete the design of the temporary sediment trap:

  1. Figures 20 may be useful in designing the sediment trap.

  2. A 3:1 aspect ration between the trap length and width of the trap is desirable. Length is defined as the average distance from the inlet to the outlet of the trap. This ratio is included in the computations for Figure 19 for the surface area at the interface between the settling zone and sediment storage volume.

  3. Determine the bottom and top surface area of the sediment storage volume to be provided (see Figure 20) using 1 1/2 feet in depth for sediment storage and 3:1 side slope from the bottom of the trap. Note the trap bottom should be level.

  4. Determine the total trap dimensions by adding the depth required for the 5-year, 24-hour design storm above the surface of the sediment storage volume, while not exceeding 3:1 side slopes see (Figure 20).

Maintenance

- The key to having a functional sediment trap is continual monitoring and regular maintenance. The size of the trap is less important to tits effectiveness than is regular sediment removal. Sediment should be removed from the trap when it reaches approximately one foot in depth (assuming a 1 1/2 sediment accumulation depth). Regular inspections should be done and

additional inspections made after each large runoff-producing storm.

All temporary and permanent erosion and sediment control practices shall be maintained and repaired as needed to assure continued performance of their intended function.

Figure 19 Structural Practices

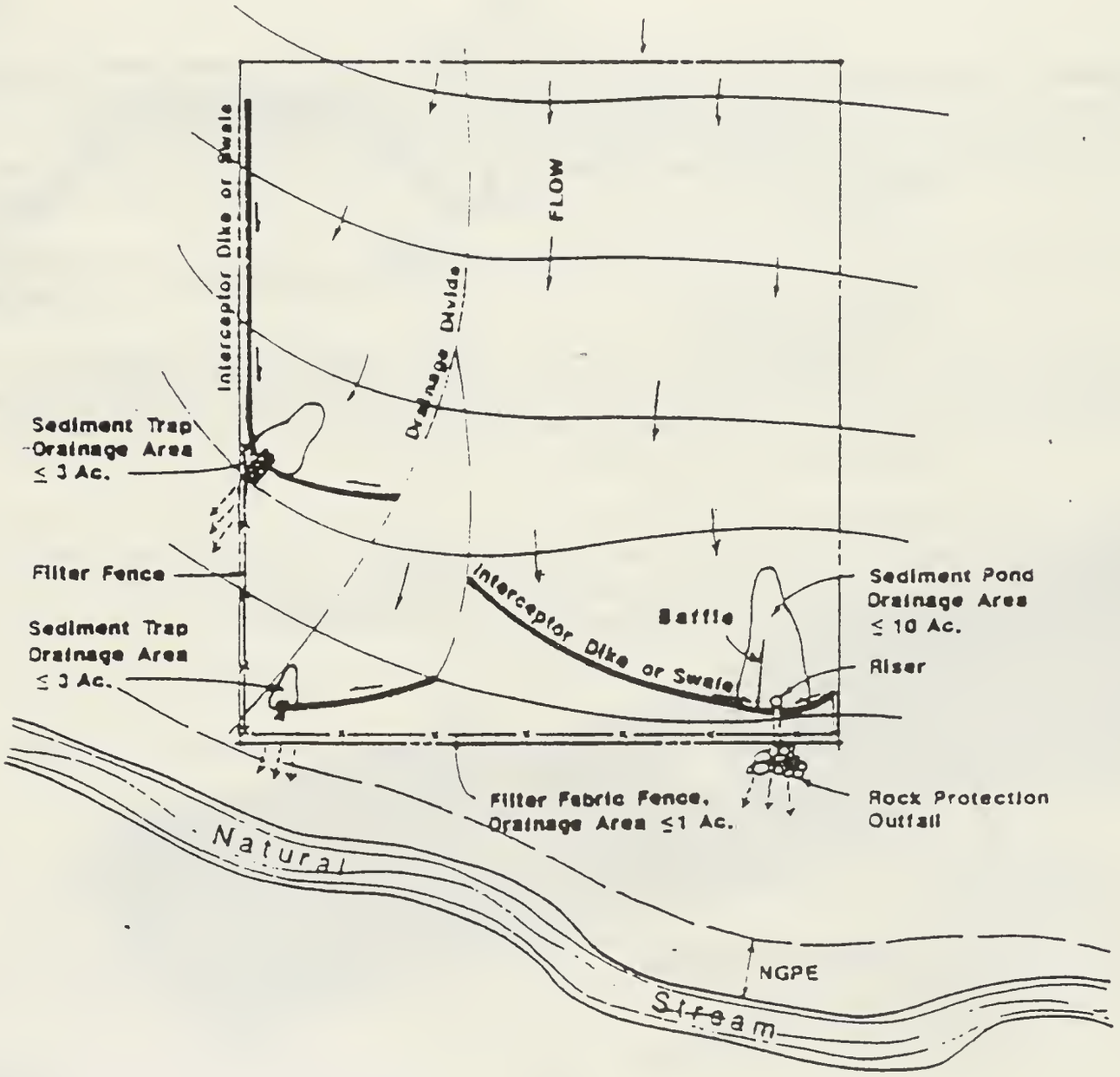
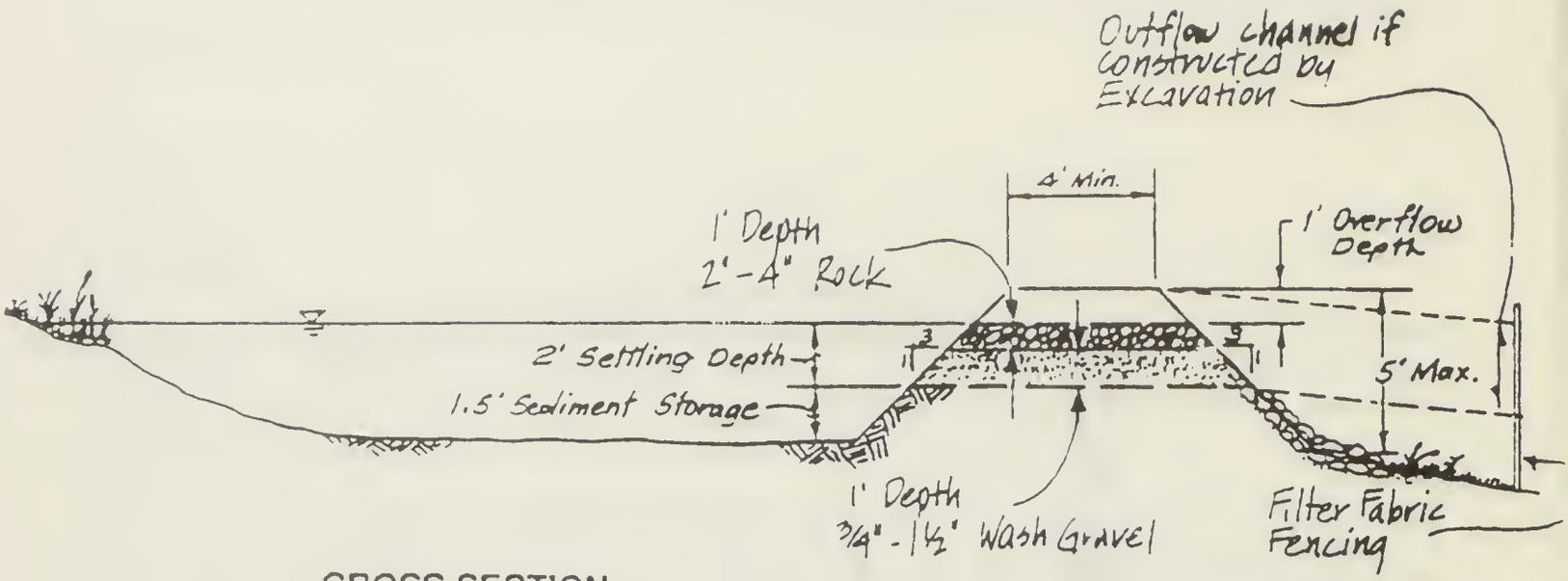
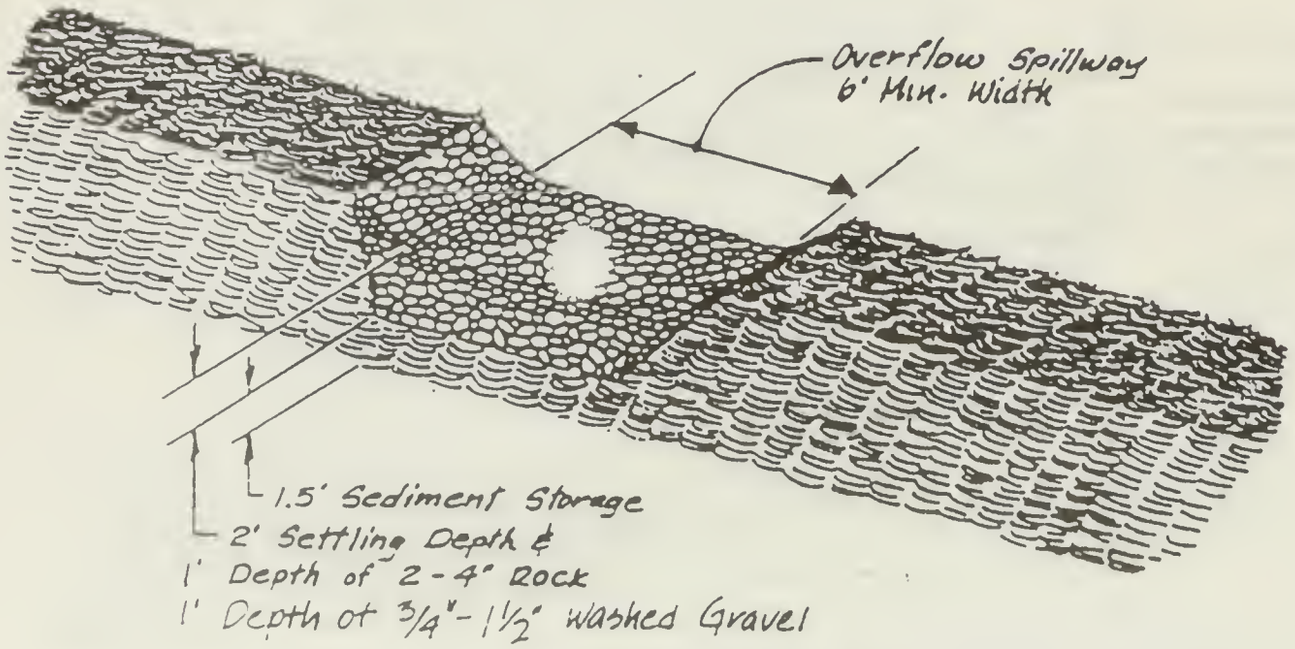


Figure 20 Sediment Trap



CROSS SECTION
NO SCALE

Note: May be constructed by excavation or by building a berm



SEDIMENT TRAP OUTLET
NO SCALE

TEMPORARY SEDIMENT POND (OR BASIN)

Symbol:

It is important to understand that sizing is perhaps less important for these BMPs (because of their temporary nature) than is constant maintenance. Inspections must be made and sediment removed regularly for either of these BMPs to function well.

Definition:

A temporary basin with a controlled stormwater release structure formed by constructing an embankment of compacted soil across a drainageway or other suitable locations.

Purpose:

To collect and store sediment from sites cleared and/or graded during construction or for extended periods of time before reestablishment of permanent vegetation and/or construction of structures. it is intended to help prevent damaging erosion on the site which results in silt-laden runoff. The basin is a temporary measure (with a design life less than 1 year) and is to be maintained until the site areas is permanently protected against erosion.

Protection of adjacent properties. Properties adjacent to the project site shall be protected from sediment deposition.

Timing and stabilization of sediment trapping measures. Sediment ponds and traps, perimeter dikes,sediment barriers, and other BMPs intended to trap sediment on-site must be constructed as a first step in grading. These BMPs must be functional before land disturbing activities take place. Earthen structures such as dams, dikes and diversions shall be seeded and mulched.

Controlling off-site erosion. Properties and waterways downstream from development sites shall be protected from erosion due to increases in the volume, velocity and peak flow rate of stormwater runoff from the project site. While conducting land disturbing activities, limit the peak rate of runoff for the 2-year, 24-hour storm to 50 percent of the release rate for existing site conditions.

Conditions Where Practice Applies

- Proposed construction sites where the tributary drainage is less than 10 acres.

Safety

Sediment traps and ponds must be installed only on sites where failure of the structure would not result in loss of life, damage to homes or buildings, or interruption of use or service of public roads or utilities. Also, sediment traps and ponds are attractive to children and can be very dangerous. Local ordinances regarding health and safety must be adhered to. if fencing of the pond is required, the type of fence and its location shall be shown on the ECP.

Advantages

- Because of additional detention time, sediment ponds may be capable of trapping smaller sediment particles than traps. However, they are most effective when used in conjunction with other BMPs such as seeding or mulching.

Disadvantages/Problems

1. Ponds may become an "attractive nuisance" and care must be taken to adhere to all safety precautions.

2. Sediment ponds are only practically effective in removing sediment down to about the medium silt size fraction. Sediment-laden runoff with smaller size fractions (fine silt and clay) will pass through untreated emphasizing the need to control erosion to the maximum extent first.

Planning Considerations

Effectiveness

Sediment basins are at best only 70-80 percent effective in trapping sediment which flows into them. Therefore, they should be used in conjunction with erosion control practices such as temporary seeding, mulching, diversion dikes, etc. to reduce the amount of sediment flowing into the basin.

Location

To improve the effectiveness of the basin, it should be located so as to intercept the largest possible amount of runoff from the disturbed area. The best locations are generally low areas below disturbed areas. Drainage into the basin can be improved by the use of diversion dikes and ditches. The basin must not be located in a stream but should be located to trap sediment-laden runoff before it enters the stream. The basin should not be located where its failure would result in the loss of life or interruption of the use or service of public utilities or roads.

Multiple Use

Sediment basins may be designed as permanent structures to remain in place after construction is completed for use as stormwater detention ponds. Wherever these structures are to become permanent, or if they exceed the size limitations of the design criteria, they must be designed as permanent ponds by a professional engineer licensed in the State of Montana.

Design Criteria

The sediment pond may be formed by partial excavation and/or by construction of a compacted embankment. It may have one or more inflow points carrying polluted runoff. Baffles to spread the flow throughout the basin should be included (gure 21). A securely anchored riser pipe is the principal discharge mechanism along with an emergency overflow spillway. The riser pipe shall be solid with two 1-inch diameter dewatering holes located at the top of the sediment storage volume on opposite sides of the riser pipe as shown in Figure 21. Outlet protection is provided to reduce erosion at the pipe outlet.

- The sediment pond volume is the sum of the sediment storage volume (3 feet in depth) plus a settling volume of not less than 2 feet in depth computed based on the basin surface area required to settle out the design particle at the design inflow rate.

  Computing the settling zone volume: The settling zone volume may be approximated by assuming a 2 foot depth above the sediment storage volume and extending the 3:1 side slopes as necessary, or by computing the precise volume as outlined below. The maximum settling zone depth shall be 4 feet.

a. Pond surface area

The settling zone volume is determined by the pond surface area which is computed using the following equation: $(SA) = 1.2\ Q_{10} / V_{bod}$

Where Q_{10} = design inflow based on the peak discharge from a 10-year, 24-hour duration design storm event from the tributary drainage area as computed using the methods described in Chapter I-1 of Volume III, Runoff Control.

V_{bod} = the settling velocity of the design soil particle. The design particle chosen is medium silt (0.02 mm) (1). This has a settling velocity V_{bod} of 0.00096 ft/sec. Note that for the relatively common sandy loam soils found in the Puget Sound basin, approximately 80 percent of the soil particles are larger than 0.02 mm. Thus choosing a design particle size of 0.02 mm gives a theoretical trapping efficiency of approximately 80 percent. In practice, and for more finely textured soils, the trapping efficiency would be less. However, as a general rule, it will not be necessary to design for a particle of size less than 0.02 mm, especially since the surface area requirement increases dramatically for smaller particle sizes. For example,a design particle of 0.01 mm requires about three times the surface area of 0.02 mm. However, for sites with very finely textured soils, the local government may require a smaller design particle size than 0.02 mm. Note also that choosing a V_{bod} of 0.00096 ft/sec equates to a surface area (SA) of 1,250 square feet pet cfs of inflow.

b. Settling depth (SD) should not be less than 2 feet and is also governed by the sediment storage volume surface area and relationship to the basin length (L). The basin length is defined as the average distance from the inlet to the outlet of the pond.

The rate of L/SD should be less than 200.

The settling volume is therefore the surface area (SA) times the required settling depth.

<u>To complete the design of the sediment pond</u>:

Total sediment pond volume and dimension are determined as outlined below:

a. The Pond Storage vs. Depth details (Figure 22) may be useful in designing the sediment pond.

b. Determine pond geometry for the sediment storage volume calculated above using 3 feet in depth and 3:1 side slopes from the bottom of the basin. Note, the basin bottom is level.

c. Extend the pond side slopes (at 3:1max.) as necessary to obtain the settling zone volume at 2 foot depth minimum or as determined above.

d. Adjust the geometry of the basin to effectively combine the settling zone volume and sediment storage volumes while preserving the depth and side slope criteria.

Provide baffles to prevent short-circuiting (see Figure 21). A 6:1 aspect ration between the basin length and width of the pond is desirable.

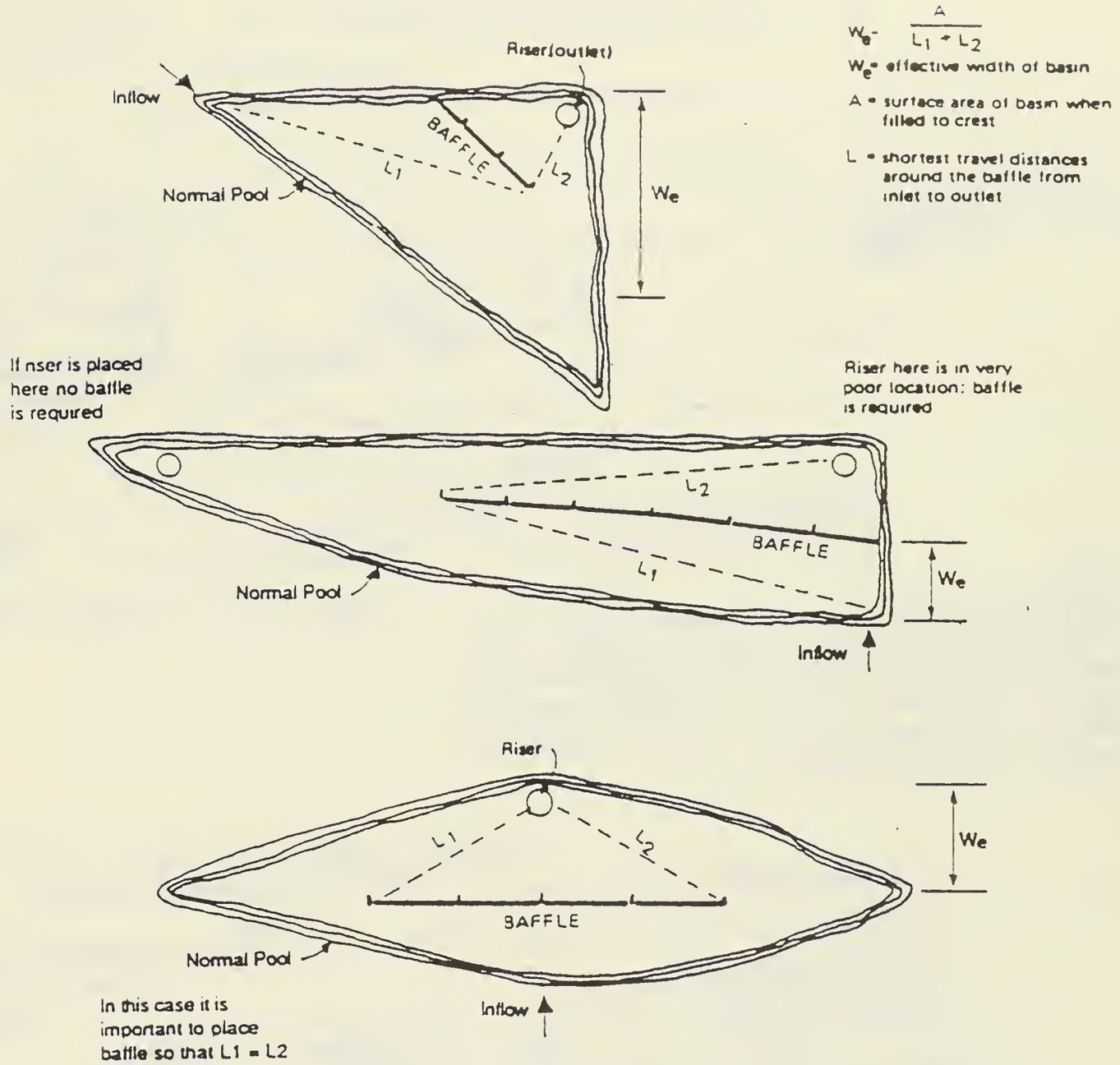
Maintenance

- Inspections should be made regularly, especially after large storm events. Sediment should be removed when it fills one half of the pond's total sediment storage area. The effectiveness of a sediment pond is based less on its size than on regular sediment removal.

All temporary and permanent erosion and sediment control practices shall be maintained and repaired as needed to assure continued performance of their intended function. All maintenance and repair shall be conducted in accordance with permit requirements.

Removal of temporary measures. All temporary erosion and sediment control measures shall be removed with 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil areas resulting from removal shall be permanently stabilized.

Figure 21 Sedimentation Pond Baffles



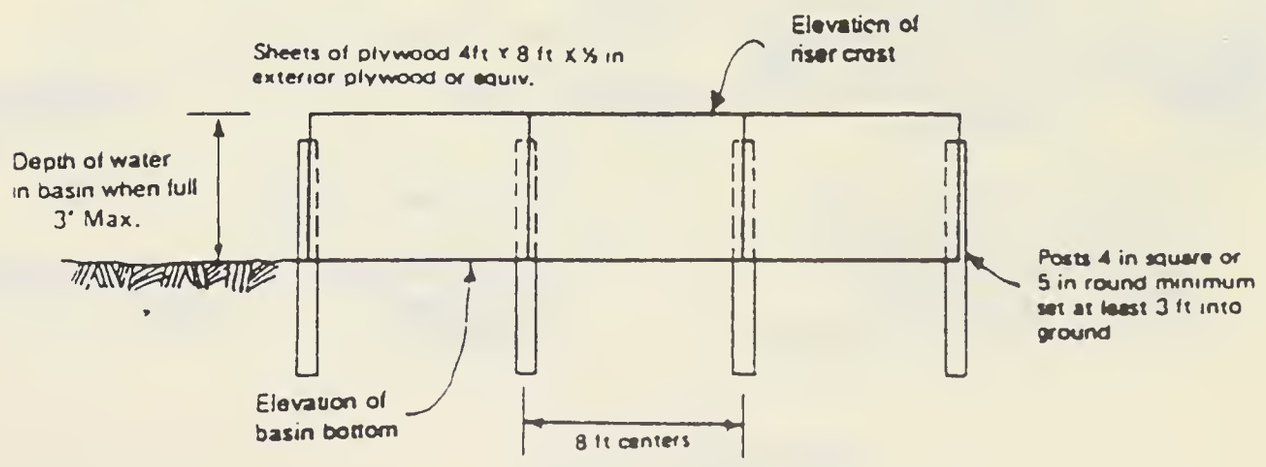
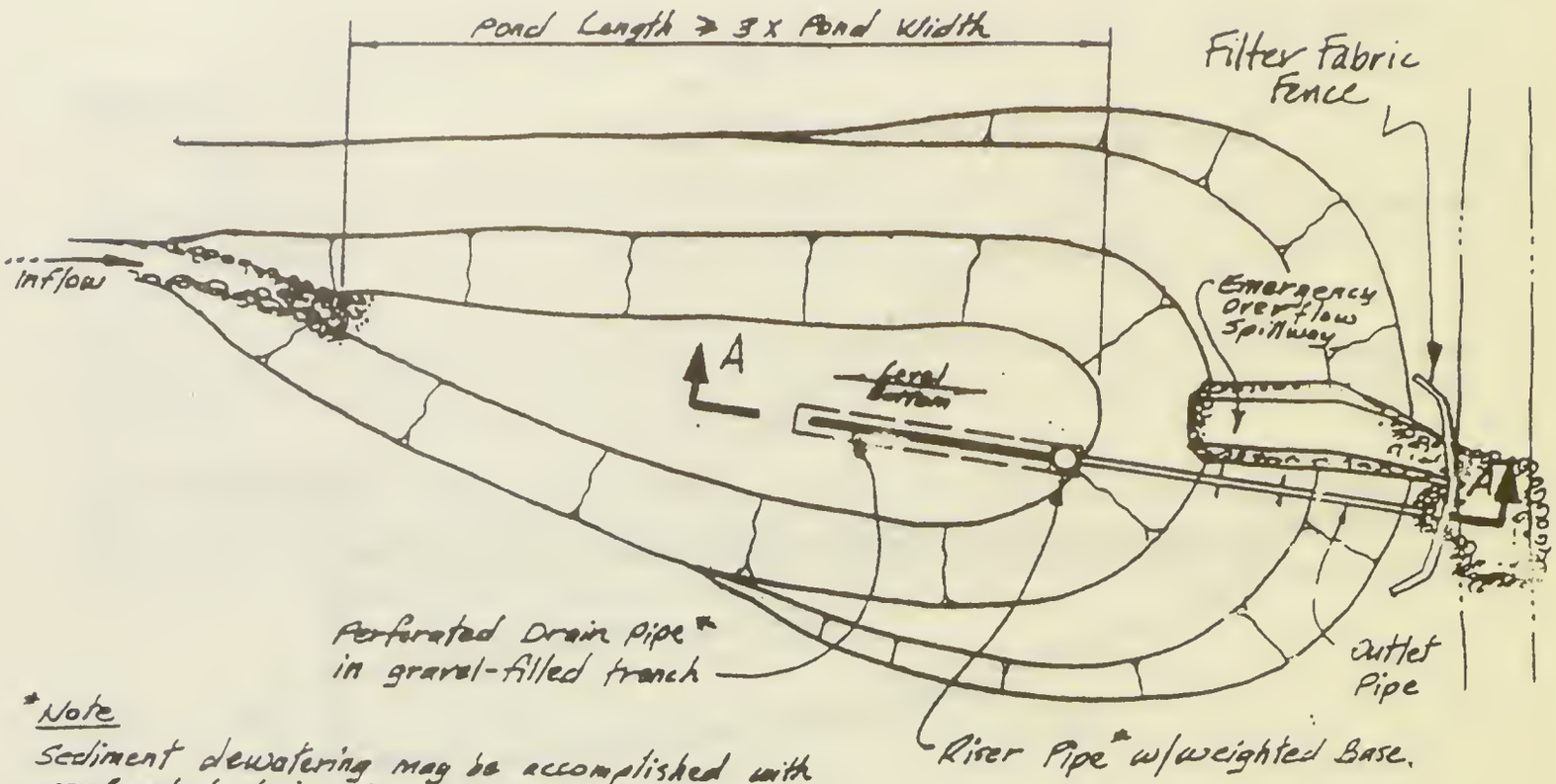
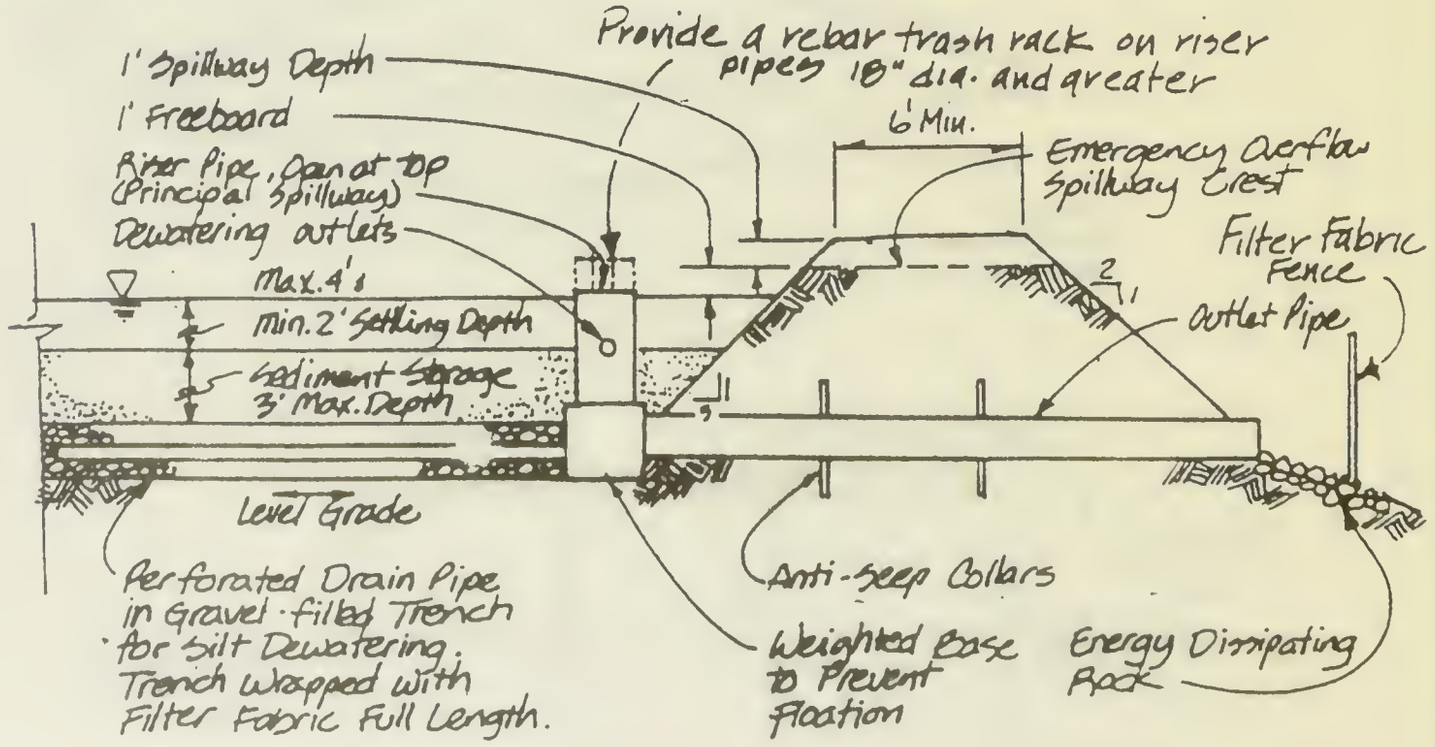

Sheets of plywood 4ft x 8 ft x ½ in exterior plywood or equiv.
Elevation of riser crest
Depth of water in basin when full 3' Max.
Posts 4 in square or 5 in round minimum set at least 3 ft into ground
Elevation of basin bottom
8 ft centers

Figure 22 Sediment Pond



*Note

Sediment dewatering may be accomplished with perforated drain pipe in trench as shown at, with a perforated riser pipe covered with filter fabric and gravel "cone". A control structure may also be required - See Item 6, Conditions where Practice Applies.


Provide a rebar trash rack on riser pipes 18" dia. and greater
1' Spillway Depth
1' Freeboard
6' Min.
Emergency Overflow Spillway Crest
Riser Pipe, Open at Top (Principal Spillway)
Dewatering outlets
Filter Fabric Fence
Max. 4'
2
1
Min. 2' Settling Depth
Outlet Pipe
Sediment Storage 3' Max. Depth
Level Grade
Perforated Drain Pipe in Gravel-filled Trench for Silt Dewatering. Trench Wrapped with Filter Fabric Full Length.
Anti-Seep Collars
Weighted Base to Prevent Flotation
Energy Dissipating Rock

SECTION A-A

CHAPTER 4

WATER QUALITY ISSUES FOR PLANNING EROSION CONTROL PLANS

4.1 STREAMSIDE MANAGEMENT ZONE

Streamside management zones are required for forest practices such as timber sales (ARM 26.6.601 et seq). Streamside management zones are very similar to buffer zones. In an effort to be consistent with current regulations, all construction activity conducted in the state should use the requirements of the streamside management zones when working in close proximately to perennial (live) streams in forested areas. Construction activities in other areas should use buffer zone specifications for projects that are adjacent to intermittent, perennial (live) streams and wetlands.

Streamside management zones (SMZ) should be designated to provide stream shading, soil stabilization, sediment and water filtering effects, and wildlife habitat. The SMZ encompasses a strip at least 50-feet wide on each side of a stream, measured from the ordinary high-water mark or definable bank. The width of the SMZ extends beyond the 50-foot minimum to include wetlands along the stream bottom and to provide additional protection in areas of steep slopes or erosive soils. "Stream" means a natural water course of perceptible extent with definite beds or banks which confine and conduct continuously or intermittently flowing water. Definite beds are defined as having a sandy or rocky bottom which results from the scouring action of water flow. Consult with forestry professionals, soil and water conservation specialists, or biologists if assistance is needed in setting appropriate stream management zone boundaries.

GUIDELINES FOR ESTABLISHING THE WIDTH OF STREAMSIDE MANAGEMNENT ZONES

1. The width of the SMZ is measured perpendicular to the stream or lake from the ordinaty high water mark to a point 50 feet distant from the ordinary high water mark. This distance is measured on each side of a stream, river or other bodies of water.

2. The width of the SMZ increases according to the following conditions:

   a. Where wetlands occur adjacent to a stream, lake or other body of water, the SMZ width increases to include the wetlands.

   b. On class 1 and 2 stream segments, the SMZ

width increases to 100 feet. Consult with the Department of Fish, Wildlife and Parks for the location of Class 1 and 2 streams in Montana.

c. On streams, lakes or other bodies of water where the slope of the adjacent topography is >35%, the SMZ width increases to 100 feet.

d. Where an established road exists between 50 and 100 feet from the ordinary high water mark for conditions in b. or c. above, the SMZ width is located at the toe of the road fill.

e. The SMZ boundary must be clearly marked prior to conducting disturbance activities.

The following activities are prohibited in the SMZ:

1. The operation of wheeled or tracked equipment except as specified in the SMZ Rules for timber harvesting practices.

2. Excavation, clearing or grubing activity.

3. Road construction except where necessary to cross a stream.

4. Road fill material must not be deposited in the SMZ.

5. The storage or disposal of hazardous and/or toxic material should not take place in the SMZ.

6. The deposition of slash material in streams, lakes or other bodies of water is prohibited.

Where possible, keep continuous openings under 600 feet of stream length. This helps to prevent increases in the water temperature and promotes wildlife habitat diversity.

4.2 PLANNING FOR WATER QUALITY PROTECTION

In developing an Erosion Control Plan (ECP) or a Storm Water Pollution Prevention Plan (SWPPP) for complinace with a storm water general discharge permit, special consideration will need to be given for certain areas and circumstances. When working in close proximaty to live streams, rivers, lakes, intermittent drainages and wetlands, special precautions should be used to prevent sediment or other pollutants from discharging to these areas.

Sediment is considered a pollutant when it is discharged to state waters in relation to development or other activities undertaken by

man. Sediment can choke young fish and "sac fry" (newly hatched fish) by interferring with oxygen uptake. The sediment settles into the stream bottom and coats the gravel where eggs are laid. Aqautic insects and algae can also be killed by sediment. Aquatic insects and algae are the main food source for fish.

Other pollutants such as petroluem products, paint, glues, fertlizers, pesticides, heavy metals, etc. degrade surface waters. Materials such as these can accidently be spilled on the ground or in surface waters. Materials spilled onto the ground become adsorbed to soil particles. The soil particles along with these pollutants can be transported to the nearest stream or wetland during a storm event. Best mamnagement practices (BMPs) must be used to control these substances as well.

4.3 GUIDELINES FOR WATER QUALITY PROTECTION

1. Use buffer zones or SMZs of 50 feet of native undisturbed vegetation on either side of a stream, river, lake or wetland whenever possible. Try to limit soil disturbance activities to a minimum of 50-100 feet from state waters.

2. Stockpiled materials, material storage and staging areas should be located a minimum of 100 feet to state waters, drainage channels, or wetlands.

3. Riparian areas should not be disturbed whenever possible. They act as natural filters and provide good buffer zones.

4. Sediment basins or ponds should not be located in a stream or a drainage channel. They should be located so as to remove the sediment-laden runoff **before** it enters the stream or drainage channel.

5. Silt fences and straw bale dikes should not be located in a stream or a natural drainage channel. They should be placed so as to trap the sediment before it reaches the stream or drainage channel.

6. Toxic and hazardous substances should be stored in secondary containment structures whenever possible. If this is not possible, store them at least 100 feet from state waters and cover them with a tarp.

7. Wetlands are important ecosystems for water quality providing natural filtering mechanisms. They should be given adequate protection from degradation due to man's activities by using proper BMPs. Sediment **should not** be allowed to discharge to natural wetlands.

8. Sediment **should not** be allowed to discharge to dry coulees or dry drainage channels. This sediment will only end up in the

nearest stream or river with the next storm event.

CHAPTER 5

EROSION AND SEDIMENT CONTROL ON INDIVIDUAL HOMESITES AND SMALL PARCELS

5.1 Background

Construction of many small developments can cause large amounts of sediment to be transported to receiving waters. Many stormwater management professionals believe that construction of individual family residences and businesses on small parcels causes more than three-quarters of all erosion problems in the area.

The erosion-sedimentation process on smaller areas is similar to that on larger areas and is primarily influenced by four factors:

1. Climate - The frequency, intensity and duration of precipitation influences the amount of runoff from a given area particularly when the ground surface is exposed or unprotected.

2. Soils - The texture, structure and organic matter content (and thus the permeability and infiltration rate) of a soil largely determines its tendency to erode.

3. Topography - The size, shape and slope characteristics (steepness, length and profile) of a watershed or a small lot within the watershed influences the amount, duration and intensity of runoff.

4. Vegetative Cover - The type, amount and consistency of vegetation and ground litter are important in keeping erosion processes to a minimum. There are a number of characteristics of an effective vegetative cover:

    a. Vegetative cover absorbs the energy of raindrops. Raindrops detach soil particles and destroy soil structure and the splash of rain hitting the ground can transport soil particles. On an erodible soil, a very heavy rainfall may splash as much as 100 tons of soil per acre of exposed land and move each particle 4 to 5 feet (4).

    b. Vegetative cover will reduce the volume and velocity of storm runoff. Vegetation absorbs water and a thick mass of vegetation on the soil surface will also serve as a barrier to prevent high velocity surface runoff.

    c. Roots aid in binding soil particles together giving the soil resistance to erosion.

d. Roots break up a heavy soil structure and increase its porosity. This increases the soils ability to absorb water. Undisturbed forest soils in the Pacific Northwest have only small amounts of surface runoff even during the largest storms.

e. Vegetation aids in removing surface and subsurface water through evapotranspiration. In a coniferous forest, evapotranspiration will release back to the air up to 40 percent of all precipitation over a year's time.

The following are some of the damaging activities and conditions that may occur during development:

- Often, exposed and unprotected soil is left throughout the development. When runoff occurs, sediment is transported into the nearest stormwater facility or stream eventually clogging it.

- Vehicles and heavy equipment track soil from the development onto the street or road. Gullies formed by tire tracks become channels for runoff flow.

- Vegetation bordering streams or lakes is often removed during construction. This increases the water temperature by removing shade. An increase in water temperature can contribute to algae blooms and may change the species composition of the lake or stream. Because the vegetation has been removed, there is no barrier to prevent sediment from entering the stream. This can clog spawning grounds and fishes' gills.

These problems may occur during work performed by subcontractors who are on-site for a very short time. cooperation and communication between buyers (or developers), builders and subcontractors are essential to minimize erosion and damage to the environment.

Some important design principles for controlling erosion and sedimentation in developing areas are as follows:

1. Plan the development to fit the particular topography, soils, waterways and natural vegetation of a site.

   a. Avoid wet areas. Wet areas can often be identified by the type of vegetation that grows there. Skunk cabbage, rushes, horsetail ferns,sedges, cattails, willows and shrubby-looking stunted red alders may be found in moist or even saturated soil conditions. Check the area during the wet season, not in the middle of the summer.

   b. Consider the effect of changes of topography. Wet areas

are often found at the base of hills. Other wet areas are found along streams, in depressions where water can collect and in natural drainageways.

c. Building on steep slopes without erosion BMPs can cause severe erosion problems because of uncontrolled, high velocity surface runoff.

2. Do not plan construction or other site disturbance activities during the rainy season.

3. Minimize the length and angles of graded slopes and fills.

4. Retain and/or properly manage runoff volume and velocity on areas subject to erosion. Divert runoff away from disturbed areas.

5. Save natural vegetation whenever possible to act as a buffer zone and help stabilize the soil.

6. Keep sediment on-site by using proper BMPs during and after construction is complete.

7. Stabilize disturbed areas immediately upon completion of earthmoving activities. Ue temporary or permanent seeding or mulches such as straw to provide immediate protection from erosion. The local Soil Conservation Service or Extension Service office can provide information on seeding mixtures and application rates. The local Soil Conservation Service may also be able to assist with the selection of proper BMPs.

8. Erosion and sediment control facilities (BMPs) must be maintained after they are installed. They must be inspected on a regular basis and repaired or replaced as necessary.

5.2 GENERAL CRITERIA FOR EROSION AND SEDIMENT CONTROLON INDIVIDUAL HOMESITES AND SMALL PARCELS

A formal erosion control Plan (ECP) is not required for small developments if the development disturbs less than 5 acres total or less than 1 acre if the disturbance is less than 100 feet to state waters. However, new development on small parcels is required to control erosion and sediment during construction and to permanently stabilize soils exposed during construction.

This requirement is met by adhering to the following General Criteria for Erosion and Sediment Control on Small Parcels (GC-SP) and implementing appropriate Small Parcel BMPs.

Small Parcel Erosion Requirement

1. The following new development is encouraged to control erosion and sediment during construction and to permanently stabilize soil exposed during construction:

   a. Individual single family residences and duplexes.

   b. Creation or addition of less than 5,000 square feet of impervious surface area.

   c. Land disturbing activities of less than one acre.

Land disturbing activities means

2. The following erosion control requirements must be met:

Construction Access Route

Construction vehicle access shall be, whenever possible, limited to one route. Access points shall be stabilized with quarry spalls or crushed rock to minimize the tracking of sediment onto public roads.

If sediment is inadvertently transported onto public roads, roads shall be cleaned thoroughly at the end of the day by shoveling or sweeping. Street washing should only be done after the bulk of the sediment has been removed by sweeping.

Stabilization of Denuded Areas

Soil stabilization. All exposed soils shall be stabilized by suitable application of sod or other vegetation, plastic covering, mulching, application of ground base on areas to be paved or other appropriate BMPs. All BMPs shall be selected, designed and maintained in accordance with this manual. From October 1 to April 30, no soils shall remain exposed for more than 2 days. From May 1 to September 30, no soils shall remain exposed for more than 7

days.

Measures should be selected which are appropriate for the time of the year and anticipated during of use.

Protection of Adjacent Properties

Adjacent properties shall be protected from sediment deposition by appropriate use of vegetative buffer strips, sediment barriers or filters, dikes or mulching, or by a combination of these measures and other appropriate BMPs.

Maintenance

All erosion and sediment control BMPs shall be regularly inspected and maintained to ensure continued performance of their intended function.

5.3 BMPS FOR SMALL PARCELS

The above General Criteria may be satisfied by employing a suitable selection from the following list of BMPs.

1. Planned Clearing and Grading

Plan and implement proper clearing and grading of the site. It is most important only to clear the areas needed, thus keeping exposed areas to a minimum. Phase clearing so that only those areas that are actively being worked are uncovered.

Note: Clearing limits should be flagged in the lot or area prior to initiating clearing.

2. Excavated Basement Soil

Locate excavated basement soil a reasonable distance behind the curb, such as in the backyard or side yard area. This will increase the distance eroded soil must travel to reach the storm sewer system. Soil piles should be covered until the soil is either used or removed. Piles should be situated so that sediment does not run into the street or adjoining yards.

3. Backfilling

Backfill basement walls as soon as possible and rough grade the lot. This will eliminate large soil mounds which are highly erodible and prepares the lot for temporary cover which will further reduce erosion potential.

4. Removal of Excess Soil

Remove excess soil from the sites as soon as possible after

backfilling. This will eliminate any sediment loss from surplus fill.

5. Management of Soil Banks

If a lot has a soil bank higher than the curb, a trench or berm should be installed moving the bank several feet behind the curb. This will reduce the occurrence of gully and rill erosion while providing a storage and settling area for stormwater.

6. Construction Road Access

Apply gravel or crushed rock to the driveway area and restrict truck traffic to this one route. Driveway paving can be installed directly over the gravel. This measure will eliminate soil from adhering to tires and stops soil from washing into the street. This measure requires periodic inspection and maintenance including washing, top-dressing with additional stone, reworking and compaction.

7. Soil Stabilization

Stabilize denuded areas of the site by mulching,seeding, planting or sodding.

8. Street Cleaning

Provide for periodic street cleaning to remove any sediment that may have been tracked out. Sediment should be removed by shovelling or sweeping and carefully removed to a suitable disposal area where it will not re-eroded.

References

(1) Goldman, Steven J., Erosion and Sediment Control Handbook, McGraw-Hill, 1986.

(2) Horner, Richard R., Juno Guedry and Michael H. Kortenhof, Highway Construction Site Erosion and Pollution Control Manual, Washington State Department of Transportation with the United States Department of Transportation Federal Highway Administration, WA-RD 200.2, January, 1990.

(3) Metro, Summary of Preliminary Data analysis - BMP survey of Single Family Residential Construction Sites, January, 1984.

(4) Brady, Nile C., The Nature and Properties of Soils. Eighth Edition, MacMillan, 1974.

CHAPTER 6

ROAD CONSTRUCTION IN FORESTED, MOUNTAINOUS AREAS

Road construction in forested, mountainous areas can be for a variety of uses such as logging roads, mining access or haul roads, recreational access, or for oil & gas activities. Regardless of the reason or purpose of the road, water quality concerns should be addressed during and following the construction activity. Proper planning of roads in these areas can eliminate many water quality problems.

6.1 Planning and Location

1. Minimize the number of roads constructed in a watershed through comprehensive road planning, recognizing intermingled ownership and foreseeable future uses. Use existing roads where practical, unless use of such roads would cause or aggravate an erosion problem

2. Review available information and consult with professionals as necessary to help identify erodible soils and unstable areas, and to locate appropriate road surface materials.

3. Fit the road to the topography by locating roads on natural benches and following natural contours. Avoid long, steep road grades and narrow canyons.

4. Locate roads on stable geology, including well-drained soils and rock formations that tend to dip into the slope. Avoid slumps and slide-prone areas characterized by steep slopes, highly weathered bedrock, clay beds, concave slopes, hummocky topography, and rock layers that dip parallel to the slope. Avoid wet areas, including moisture-laden or unstable toe slopes, swamps, wet meadows, and natural drainage channels.

5. Locate roads a safe distance from streams when roads are running parallel to stream channels. Provide an adequate streamside management zone (SMZ) to trap sediment and prevent its entry into the stream.

6. Minimize the number of stream crossings and choose stable stream crossings.

7. Locate roads to provide access to suitable (relatively flat and well-drained) staging areas to reduce soil disturbance.

6.2 Design

1. Properly design roads and drainage facilities to prevent potential water quality problems from road construction.

2. Design roads to the minimum standard necessary to accommodate anticipated use and equipment. The need for higher standard roads can be alleviated through better road-use management.

3. Design roads to balance cuts and fills or use full bench construction (no fill slope) where stable fill construction is not possible.

4. Design roads for minimal disruption of drainage patterns. Vary road grades to reduce concentrated flow in road drainage ditches, culverts, and on fill slopes and road surfaces.

5. Design stream-crossings for adequate passage of fish (if present), minimum impact on water quality, and at a minimum, the 25-year frequency runoff.

6.3 Drainage from Road Surface

1. Provide adequate drainage from the surface of all permanent and temporary roads by using outsloped or crowned roads, drain dips, or insloped roads with ditches and crossdrains. Space road drainage features so peak drainage flow on the road surface or in ditches will not exceed the capacity of the individual drainage facilities.

   a. Outsloped roads provide means of dispersing water in a low-energy flow from the road surface. Outsloped roads are appropriate when fill slopes are stable, drainage will not flow directly into stream channels, and transportation safety considerations can be met.

   b. For insloped roads, plan ditch gradients steep enough, generally greater than 2%, but less than 8%, to prevent sediment deposition and ditch erosion. The higher gradients may be suitable for more stable soils; use the lower gradients for less stable soils.

   c. Properly constructed drain dips can be an economical method of channeling surface flow off the road. Construct drain dips deep enough into the subgrade so that traffic will not obliterate them.

2. Skew ditch relief culverts 20 to 30 degrees toward the inflow from the ditch to improve inlet efficiency. Protect the upstream end of cross-drain culverts from plugging.

3. Where possible, install ditch relief culverts at the gradient of the original ground slope; otherwise armor outlets with rock or anchor downspouts to carry water safely across the fill slope.

4. Provide energy dissipators (rock piles, logs, etc.) where necessary at the downstream end of ditch relief culverts to reduce the erosion energy of the emerging water. Crossdrains, culverts, water bars, dips, and other drainage structures should not discharge onto erodible soils or fill slopes without outfall protection.

5. Prevent downslope movement of sediment by using sediment catch basins, drop inlets, changes in road grade, headwalls, or recessed cut slopes.

6. Route road drainage through the stream management zone, filtration fields, or other sediment settling structures. Install road drainage features above stream crossings to route discharge into filtration zones before entering a stream.

6.4 Construction

1. Keep slope stabilization, erosion and sediment control work as current as possible with road construction. This includes installing drainage features as part of the construction process. Complete or stabilize road sections within the same operating season, ensuring that drainage structures are fully functional prior to spring or fall runoff and that major road sections are not left in an unstable condition over winter.

2. Stabilize erodible, exposed soils by seeding, riprapping, benching, mulching, or other suitable means prior to fall or spring runoff.

3. At the toe of potentially erodible fill slopes, particularly near stream channels, pile slash in a row parallel to the road to trap sediment. When done concurrently with road construction, this practice can effectively control sediment movement and can provide an economical way of disposing of roadway slash. Limit the height, width and length of these "slash filter windrows" so not to impede wildlife movement.

4. Minimize earth-moving activities when soils appear excessively wet. Do not disturb roadside vegetation more than necessary to maintain slope stability and to serve traffic needs.

5. Construct cut and fill slopes at stable angles.

6. Avoid incorporating potentially unstable woody debris in the fill portion of the road prism. Where possible, leave existing rooted trees or shrubs at the toe of the fill slope to stabilize the fill.

7. Consider road surfacing to minimize erosion.

8. Place debris, overburden, and other waste materials associated with construction and maintenance activities in a location to avoid entry into streams. Include these waste areas in soil stabilization planning for the road.

9. Minimize sediment production from borrow pits and gravel sources through proper location, development and reclamation.

10. When using existing roads, reconstruct only to the extent necessary to provide adequate drainage and safety; avoid disturbing stable road surfaces.

6.5 Maintenance

1. Grade road surfaces only as often as necessary to maintain a stable running surface and to retain the original surface drainage.

2. Maintain erosion control features through periodic inspection and maintenance, including cleaning dips and crossdrains, repairing ditches, marking culvert inlets to aid in location, and clearing debris from culverts.

3. Avoid cutting the toe of cut slopes when grading roads or pulling ditches.

4. When plowing snow for winter timber harvest, provide breaks in snow berm to allow road drainage.

5. Haul all excess material removed by maintenance operations to safe disposal sites and stabilize these sites to prevent erosion. Avoid side-casting material into streams or locations where erosion will carry materials into a stream.

6. Avoid using roads during wet periods if such use would likely damage the road drainage features.

7. Upon completion of seasonal operations, the road surface should be crowned, outsloped, insloped, or water-barred. Remove berms from the outside edge where runoff is channeled.

8. Leave abandoned roads in a condition that provides adequate drainage without further maintenance. Close these roads to traffic; reseed and/or scarify; and, if necessary, recontour and provide water bars or drain dips.

Brush barriers - a sediment barrier composed of brush and material cleared from the site during grading or from cleaning and grubbing. Is composed of limbs, small vegetation, and root matter with small amounts of soil and rock material placed in a row at the base of a slope or areas where sheet and rill erosion are likely to occur (See Figure II-4.20).

Brush barriers are temporary control practices that can prevent off-site erosion. Work best for controlling erosion for areas less than 1/4 acre in size. Can be used in conjunction with other BMPs or until permanent BMPs can be installed.

Check dams - small dams composed of logs, stone, or pea gravel filled sand bags built across a swale or drainage ditch (not a stream or creek). See Figure II-4.13.

Check dams are generally temporary in nature but can become permanent with minor regrading. They work to reduce flow velocities and prevent gully erosion. Sediment will generally settle out behind the check dam. They work best for the drainage of small channels draining less than 10 acres. May be used in combination with other BMPs.

Drain inlet protection - a filter designed to prevent sediment and debris from entering or blocking a storm drain inlet. The filter can be composed of filter fabric fence material, block and gravel, or gravel and wire mesh (See Figure II-4.22 & II-4.23).

Drain inlet protection is generally a permanent structure which requires periodic cleaning and maintenance. This BMP works best in conjunction with sediment ponds or barriers.

Drainage swales - are grassed or vegetated swales located above, at mid-slope or below a disturbed slope to divert runoff to a more stabilized area or outlet. Also see grassed waterway.

Drainage swales are generally used in conjunction with an interceptor dike which collects or intercepts the runoff. This is a temporary but practical method for diverting runoff away from erosive areas. Generally diverts water to a sediment pond or basin, a filtration trench or basin, or a dry pond (See Figure II-4.12 (b)).

Dry ponds - are ponds designed to store excess storm water and release the water after the peak of the storm event has passed. These ponds are designed to contain runoff from the 2 year or more frequent storms and detain the water for 40 hours or more before being released via biofilter. They are commonly referred to as extended detention dry ponds.

This is a permanent storm water management practice which improves water quality by allowing most particulate matter and pollutants to settle out before the water from the pond is released. Dry ponds work best when constructed in a series with a biofilter or used with other BMPs.

Earth dikes - are interceptor dikes composed of soil materials from the site. Earth interceptor dikes are placed on the downslope side of a drainage swale to retard runoff so that it is collected and diverted (See Figure II-4.12 (a)).

Earth dikes are used with the same BMP combinations as the drainage swale and is usually a temporary measure. If the earth dike remains in place for longer than 15 days, it should be stabilized with mulch or temporary seeding.

Erosion control blankets - are a form of mulch produced commercially and composed of wood strips or chips, straw, or coconut fibers held together by a plastic mesh. They come in 50 to 100 feet rolls. Plastic sheeting and polyester fabrics are also used as erosion control blankets.

Erosion control blankets provide quick slope stabilization and are usually applied after a site has been seeded. They provide moisture for the new seedlings, prevent the soil from drying out, and protect the soil from erosion.

Filter strips - strips of natural vegetation, tall grass species, or woody shrubs that provide a living filter to trap sediment and reduce runoff flow velocities. Also see vegetative buffer strips.

Filter strips can be used for both temporary and permanent control practices. They can be used in conjunction with wet ponds or artificially created wetlands.

Grassed waterways - are natural drainages which have been stabilized by planting grass species adapted to wet site conditions. They are designed to prevent gully erosion by providing properly proportioned channels protected by vegetation.

Grassed waterways work best when used in conjunction with sediment basins or ponds, infiltration trenches or basins, or dry and wet ponds. The water is naturally diverted to an area where the water will infiltrate into the ground or will allow the sediment to settle out over time. They can be used on a temporary or a permanent basis.

Infiltration basins/trenches - are basins or trenches designed for storm water infiltration into the ground or soils. These practices are not designed to trap coarse sediments. Coarse sediments should be removed prior to the water reaching the infiltration structure.

An infiltration trench is a shallow excavated trench that has been backfilled with stone or pea gravel to form an underground reservoir. These trenches require special site conditions and are generally best on sites less than 10 acres in size. This BMP works best when used in conjunction with filter strips or special inlets to capture sediment. They can be temporary or permanent structures.

An infiltration basin is an area designed to capture and hold storm water allowing for it to infiltrate into the soil below. This basin requires specific site conditions also (permeable soils, water table or bedrock >25 feet below the ground surface). Infiltration basins can be used on larger sites and may be designed to retain runoff from up to 50 acres. They can also be designed as an infiltration/detention basins. They are sometimes referred to as dry ponds. These basins are generally permanent structures.

Level spreaders - are dikes or diversions which capture the runoff and evenly distribute it on the surface of the land. They are designed to convert runoff to sheet flow and release it on a vegetated stable surface (See Figure II-4.11).

The level spreader is easily installed and inexpensive to use. Special care must be taken in the design to prevent concentrated flows from occurring.

Mulching - is the application of plant residue or other materials to the soil surface. Soil mulching provides many functions - protects seedlings until they are established, provides moisture to seedlings, prevents soil drying, and protects the surface from erosion.

Many materials can be used for mulching - straw, shredded corn stalks, wood chips, bark, wood fiber, plastic sheeting, gravel, erosion control blankets, and commercial nets and matting. Mulches are the best and most practical method of preventing erosion. They can used for both temporary control and to establish permanent seed cover (See Figure II-4.1 & Table II-4.1).

Pipe slope drain - is a pipe that runs from the top of a slope to the bottom which discharges storm water onto a stable surface. Pipe slope drains prevent gully erosion, channeling, and soil slides (See Figure II-4.4).

Pipe slope drains can be used temporarily or permanently. they work best when used to discharge storm water to water coarse, sediment trapping device, or to a stabilized area.

Preserving existing trees - by clearing small areas at a time and preserving larger trees whenever possible, the area exposed to erosion is limited. By reducing erosion, costs are lowered because fewer BMPs are needed to control runoff.

Whenever possible and practical, natural vegetation should be preserved. Not only will natural vegetation prevent erosion, it provides aesthetic value, increases property values, and provides wildlife habitat.

Retaining walls - are walls built to prevent soil erosion and sloughing. They can be made of logs, railroad ties, stone or rock, or concrete blocks. They prevent soil loss from very steep or unstable slopes (See Figure II-2.6).

Retaining walls are generally permanent structures but can used on a temporary basis in some instances.

Rock outlet protection - is a rock lined apron or other energy dissipating device located at outlets, pipes, or channel sections. They are designed to reduce the velocity of concentrated storm water flows and prevent scour at outlets.

Rock outlet protection can be used on a permanent or a temporary basis.

Sediment basin/pond - a temporary basin or pond designed to collect storm water and the settling out of soil particles for extended periods of time. They have a controlled storm water release structure (See Figure II-4.28).

Sediment basins/ponds are generally used as a temporary control for sites which drain less than 10 acres. The lifespan for these structures is less than 1 year. Requires routine maintenance to be effective. Are most effective when used in conjunction with practices such as temporary seeding, mulching, diversion dikes, which reduce the amount of sediment flowing into them.

Sediment traps - a small pond or excavated area used temporarily for the collection of storm water and the settling out of soil particles. They generally have a gravel outlet for water release (See Figure II-4.26 & II-2.17).

Sediment traps are most commonly used for temporary sediment control on small building sites. The average lifespan is approximately 6 months. Permanent sediment traps are produced commercially for municipal storm water sewer systems. These structures require routine maintenance to be effective. They are most effective when used with the BMPs mentioned above for sediment basins.

Seeding - is the establishment of vegetative cover on disturbed areas. Generally rapid growing annuals (grasses and legumes) are used to establish temporary cover. More indigenous (native) plant species may be necessary for permanent seeding in some areas of the state.

Seeding for erosion control can be on a temporary basis or for permanent control. This is generally the most cost effective means of erosion control. The most common and successful species used are grasses and legumes. A properly prepared seedbed is a must and seeding is most successful when used with mulching in low rainfall areas or on steep slopes (See Figure II-2.8).

Silt fences - a sediment fence composed of synthetic filter fabric. It is used to detain small amounts of sediment from disturbed areas less than 1 acre in size.

Silt fences are temporary devices to prevent sediment from leaving the site. They work best when used in conjunction with sediment ponds or traps and perimeter dikes. Silt fences effectively remove sediment when installed properly. Research conducted by the Virginia Highway and Research Council indicates silt fences can trap a much higher percentage of sediment as opposed to straw bales.

Sod stabilization - is the use of sod strips or stands to stabilize disturbed areas. Sod stabilization provides an immediate protective cover of vegetation.

The use of sod to stabilize a site is usually a permanent means of cover. Sod is quite expensive and therefore, not cost effective for temporary control. This BMP works best on steep slopes or areas which need immediate protective cover. Can also be used to establish cover in grassed waterways.

Straw bale dikes - is the use of straw bales to create a temporary dike for trapping sediment in swales or drainage ditches.

The use of straw bale dikes is a temporary measure for controlling runoff from small sites draining no more than 2 acres. When used properly, they provide an inexpensive means of sediment control. See Figure II-4.19 for instructions on proper installation.

Subsurface drain - is a perforated pipe, tubing or conduit placed beneath the soil surface and used to drain excessively wet, sloping soils. Note: a federal permit is required to dewater a naturally occurring wetland.

A subsurface drain can either be a relief drain or an interceptor drain. A relief drain is installed along a slope and drains in the direction of the slope. An interceptor drain is used to remove water as it seeps down a slope and prevents soils slippage. Interceptor drains are usually installed across the slope. Both types of drains are permanent structures (See Figure II-4.5).

Terracing slopes - terraced slopes are steep slope faces which have had small stair type cuts placed perpendicular to the slope and run the full width of a slope face (See Figure II-4.8). This practice

is called stair-stepping cut slopes in some areas of the country.

Terraced slopes reduce the velocity of runoff and trap sediment and debris from upslope. This practice is generally a permanent means of stabilizing steep and long slopes. Water, soil, and nutrients are effectively held so that plants can become established with this design. This practice is quite effective when used with permanent seeding.

Tree and shrub planting - trees and shrub species can provide excellent sediment and erosion control. They protect the soil from erosive forces such as raindrop impact and sheet or rill flow. Their branches reduce raindrop velocities while their roots provide an effective network for holding the soil in place.

Tree and shrub planting is a permanent practice with added benefits. These plant species provide natural beauty, wildlife habitat, and increase property values. They can also be planted as vegetative buffer strips or as wind breaks(see below).

Vegetative buffer strips - are natural vegetative filters which trap sediment on-site. They are similar to filter strips but are generally located adjacent to streams, rivers, and lakes to protect the water bodies from harmful sediment loads.

Buffer strips are generally a permanent measure for protecting surface waters. The buffer strips are usually 50-100 feet wide on either side of a stream or river or surrounding a lake. They work best when used with other sediment controlling practices such as sediment traps or basins.

Wet ponds - are ponds designed to collect storm water and release it slowly after the peak storm event similar to a dry pond. However, a wet pond continues to hold water in between storm events where a dry pond does not. They are also referred to as extended detention ponds.

Wet ponds are also a permanent storm water management practice that controls runoff and improves water quality. Wet ponds can be developed from temporary sediment basins but they must designed properly. A permanent pond structure requires a more careful plan of design than a temporary structure. Man-made marshes and wetlands fit into this category as well with specific design criteria and the establishment of wetland plant species.

Wet ponds are quite effective for removing pollutants from storm water. The design criteria is similar to the dry pond, the 2 year/24 hour storm event. For better flood control and streambank protection, these ponds can be designed for the 10 year or 100 year, 24 hour storm event.

APPENDIX

APPENDIX

Typical "C" Values (ASCE 1960)

Description of Area	Runoff Coefficients
Business	
Downtown Areas	0.70-0.95
Neighborhood Areas	0.50-0.70
Residential	
Single-family areas	0.30-0.50
Multiunits, detached	0.40-0.60
Multiunits, attached	0.60-0.75
Residential (suburban)	0.25-0.40
Apartment dwelling areas	0.50-0.70
Industrial	
Light Areas	0.50-0.80
Heavy areas	0.60-0.90
Parks, cemeteries	0.10-0.25
Playgrounds	0.20-0.35
Railroad yard areas	0.20-0.40
Unimproved areas	0.10-0.30
Streets	
Asphalt	0.70-0.95
Concrete	0.80-0.95
Brick	0.70-0.85
Drives and walks	0.75-0.85
Roofs	0.75-0.95
Lawns - course textured soil (greater than 85% sand)	
Slope: Flat, 2%	0.05-0.10
Average, 2-7%	0.10-0.15
Steep, 7%	0.15-0.20
Lawns - fine textured soil (greater than 40% clay)	
Slope: Flat, 2%	0.13-0.17
Average, 2-7%	0.18-0.22
Steep, 7%	0.25-0.35

Calculating Weighted "C" Values

$$C = \frac{(5\ ac.\ x\ .9) + (5\ ac.\ x\ .2) + (5\ ac.\ x\ .1)}{(5\ ac. + 5\ ac. + 5\ ac.)}$$

$$C = \frac{(4.5\ ac.) + (1.0\ ac.) + (.5\ ac.)}{(15\ ac.)}$$

$$C = \frac{6.0\ ac.}{15\ ac.}$$

$$C = .4$$

MONTANA WATER QUALITY BUREAU

STORM WATER EROSION CONTROL CHECKLIST

Construction Activity

_____ Sediment and erosion controls

_____ Vegetative practices initiated within 14 days of disturbance

_____ >10 ac. disturbed, detention basin for 10 year, 24 hour storm

_____ Silt fences or equivalent controls for downslope boundaries

_____ Storm water BMP controls after construction is completed

_____ Velocity dissipation at outfalls

_____ Proper waste disposal - complies with State regulations

_____ Off-site vehicle tracking for sediment control

_____ Designated areas for equipment maintenance and repair

_____ Location of equipment washdown areas and control of washwater

_____ Protected storage areas for chemicals, paints, solvents, fertilizers, and other potentially toxic materials

EXAMPLE STORM WATER EROSION CONTROL PLAN

The following plan was borrowed from EPA's Storm Water Management for Construction Activity.

SITE DESCRIPTION

Project Name and Location: (Latitude, Longitude, or Address)	Homerville Apartments 21 Broadview Avenue Center City, ANY STATE 00000	**Owner Name and Address:**	Quality Associates 11 Main Street Center City, ANY STATE 00000

Description: (Purpose and Types of Soil Disturbing Activities)

This project will consist of three low-rise, attached apartment buildings with adjacent parking facilities.

Soil disturbing activities will include: clearing and grubbing; installing a stabilized construction entrance, perimeter, and other erosion and sediment controls; grading; excavation for the sedimentation pond, storm sewer, utilities, and building foundations; construction of curb and gutter, road, and parking areas; and preparation for final planting and seeding.

Runoff Coefficient:	The final coefficient of runoff for the site will be c = 0.5.
Site Area:	The site is approximately 11.0 acres of which 9.8 acres will be disturbed by construction activities.

Sequence of Major Activities

The order of activities will be as follows:

1. Install stabilized construction entrance
2. Clear and grub for earth dike and sediment basin
3. Install earth dike
4. Construct sedimentation basin
5. Continue clearing and grading
6. Pile topsoil
7. Stabilize denuded areas and stockpiles within 14 days of last construction activity in that area
8. Install utilities, storm sewer, curb and gutter
9. Apply stone to parking area and road
10. Construct apartment buildings
11. Complete grading and install permanent seeding and plantings
12. Complete final paving
13. Remove accumulated sediment from basin.
14. When all construction activity is complete and the site is stabilized, remove earth dike and reseed any areas disturbed by their removal.

Name of Receiving Waters:	The entire site will drain into Rocky Creek which is approximately one hundred yards from the site.

CONTROLS

Erosion and Sediment Controls

Stabilization Practices

Temporary Stabilization - Top soil stock piles and disturbed portions of the site where construction activity temporarily ceases for at least 21 days will be stabilized with temporary seed and mulch no later than 14 days from the last construction activity in that area. The temporary seed shall be Rye (grain) applied at the rate of 120 pounds per acre. Prior to seeding, 2,000 pounds of ground agricultural limestone and 1,000 pounds of 10-10-10 fertilizer shall be applied to each acre to be stabilized. After seeding, each area shall be mulched with 4,000 pounds per acre of straw. The straw mulch is to be tacked into place by a disk with blades set nearly straight. Areas of the site which are to be paved will be temporarily stabilized by applying geotextile and stone sub-base until bituminous pavement can be applied.

Permanent Stabilization - Disturbed portions of the site where construction activities permanently ceases shall be stabilized with permanent seed no later than 14 days after the last construction activity. The permanent seed mix shall consist of 80 lbs/acre tall fescue, and 40 lbs/acre kobe lespedeza. Prior to seeding, 4,000 pounds of ground agricultural limestone and 2,000 pounds of 10-10-10 fertilizer shall be applied to each acre to be stabilized. After seeding, each area shall be mulched with 4,000 pounds per acre of straw. The straw mulch is to be tacked into place by a disk with blades set nearly straight.

CONTROLS (Continued)

Structural Practices

Earth Dike - will be constructed along the uphill perimeter (north) of the site. A portion of the dike will divert runon around the construction site. The remaining portion of the dike will collect runoff from the disturbed area and direct the runoff to the sediment basin.

Sediment Basin - will be constructed at the common drainage location on the south side of the construction site. The basin will be formed by constructing an embankment across an existing gully and excavating a storage pond with a volume of 36,000 cubic feet (0.82) acre feet. The basin will drain through a corrugated metal riser and outlet pipe to a rip rap outlet apron. Once construction activities are nearly complete, the accumulated sediment will be removed from the basin.

Storm Water Management

Storm water drainage will be provided by curb and gutter, storm sewer and catch basin, for the developed areas. The areas which are not developed will be graded at less that 0.5:1 and have permanent seeding or plantings. Two acres of the site will remain untouched and in its natural state. When construction is complete the entire site will drain to a wet detention basin. The wet detention basin will be in the location of the temporary sediment basin. When upslope areas are stabilized, the accumulated sediment will be removed from the sediment basin, and the areas on the sides of the basin will be planted with vegetation. The wet detention pond is designed with a permanent pool volume of 0.82 (acre-feet). This is equivalent to one inch of runoff for the entire drainage area. It is expected that this wet detention pond design will result in an 80 percent removal of total suspended solids from the site's storm water runoff. The pond has been designed by a professional engineer to keep peak flow rates from the two and ten year/24 hour storms at their pre-development rates. The outlet of the detention basin will be stabilized by a riprap apron.

OTHER CONTROLS

Waste Disposal:

Waste Materials

All waste materials will be collected and stored in a securely lidded metal dumpster rented from the ADF Waste Management Company, which is a licensed solid waste management company in Center City. The dumpster will meet all local Center City and any State solid waste management regulations. All trash and construction debris from the site will be deposited in the dumpster. The dumpster will be emptied a minimum of twice per week or more often if necessary, and the trash will be hauled to the Center City Dump. No construction waste materials will be buried onsite. All personnel will be instructed regarding the correct procedure for waste disposal. Notices stating these practices will be posted in the office trailer and Mr. Doe, the individual who manages the day-to-day site operations, will be responsible for seeing that these procedures are followed.

Hazardous Waste

All hazardous waste materials will be disposed of in the manner specified by local or State regulation or by the manufacturer. Site personnel will be instructed in these practices and Mr. Doe, the individual who manages day-to-day site operations, will be responsible for seeing that these practices are followed.

Sanitary Waste

All sanitary waste will be collected from the portable units a minimum of three times per week by the TIDEE Company, a licensed Center City sanitary waste management contractor, as required by local regulation.

Offsite Vehicle Tracking:

A stabilized construction entrance has been provided to help reduce vehicle tracking of sediments. The paved street adjacent to the site entrance will be swept daily to remove any excess mud, dirt or rock tracked from the site. Dump trucks hauling material from the construction site will be covered with a tarpaulin.

TIMING OF CONTROLS/MEASURES

As indicated in the Sequence of Major Activities, the earth dike, stabilized construction entrance and sediment basin will be constructed prior to clearing or grading of any other portions of the site. Areas where construction activity temporarily ceases for more than 21 days will be stabilized with a temporary seed and mulch within 14 days of the last disturbance. Once construction activity ceases permanently in an area, that area will be stabilized with permanent seed and mulch. After the entire site is stabilized, the accumulated sediment will be removed from the trap and the earth dike will be removed.

CERTIFICATION OF COMPLIANCE WITH FEDERAL, STATE, AND LOCAL REGULATIONS

The storm water pollution prevention plan reflects Center City requirements for storm water management and erosion and sediment control, as established in Center City ordinance 5-188. To ensure compliance, this plan was prepared in accordance with the Center City Storm Water Management, Erosion and Sediment Control Handbook, published by the Center City Department of Planning, Storm Water Management Section. There are no other applicable State or Federal requirements for sediment and erosion site plans (or permits), or storm water management site plans (or permits).

MAINTENANCE/INSPECTION PROCEDURES

Erosion and Sediment Control Inspection and Maintenance Practices

These are the inspection and maintenance practices that will be used to maintain erosion and sediment controls.

- Less than one half of the site will be denuded at one time.
- All control measures will be inspected at least once each week and following any storm event of 0.5 inches or greater.
- All measures will be maintained in good working order; if a repair is necessary, it will be initiated within 24 hours of report.
- Built up sediment will be removed from silt fence when it has reached one-third the height of the fence.
- Silt fence will be inspected for depth of sediment, tears, to see if the fabric is securely attached to the fence posts, and to see that the fence posts are firmly in the ground.
- The sediment basin will be inspected for depth of sediment, and built up sediment will be removed when it reaches 10 percent of the design capacity or at the end of the job.
- Diversion dike will be inspected and any breaches promptly repaired.
- Temporary and permanent seeding and planting will be inspected for bare spots, washouts, and healthy growth.
- A maintenance inspection report will be made after each inspection. A copy of the report form to be completed by the inspector is attached.
- Mr. Doe, site superintendent, will select three individuals who will be responsible for inspections, maintenance and repair activities, and filling out the inspection and maintenance report.
- Personnel selected for inspection and maintenance responsibilities will receive training from Mr. Doe. They will be trained in all the inspection and maintenance practices necessary for keeping the erosion and sediment controls used onsite in good working order.

MAINTENANCE/INSPECTION PROCEDURES (Continued)

Non-Storm Water Discharges

It is expected that the following non-storm water discharges will occur from the site during the construction period:

- Water from water line flushings.
- Pavement wash waters (where no spills or leaks of toxic or hazardous materials have occurred).
- Uncontaminated groundwater (from dewatering excavation).

All non-storm water discharges will be directed to the sediment basin prior to discharge.

INVENTORY FOR POLLUTION PREVENTION PLAN

The materials or substances listed below are expected to be present onsite during construction:

- Concrete
- Detergents
- Paints (enamel and latex)
- Metal Studs
- Concrete
- Tar
- Fertilizers
- Petroleum Based Products
- Cleaning Solvents
- Wood
- Masonry Block
- Roofing Shingles.

SPILL PREVENTION

Material Management Practices

The following are the material management practices that will be used to reduce the risk of spills or other accidental exposure of materials and substances to storm water runoff.

Good Housekeeping:

The following good housekeeping practices will be followed onsite during the construction project.

- An effort will be made to store only enough product required to do the job
- All materials stored onsite will be stored in a neat, orderly manner in their appropriate containers and, if possible, under a roof or other enclosure
- Products will be kept in their original containers with the original manufacturer's label
- Substances will not be mixed with one another unless recommended by the manufacturer
- Whenever possible, all of a product will be used up before disposing of the container
- Manufacturers' recommendations for proper use and disposal will be followed
- The site superintendent will inspect daily to ensure proper use and disposal of materials onsite.

Hazardous Products:

These practices are used to reduce the risks associated with hazardous materials.

- Products will be kept in original containers unless they are not resealable
- Original labels and material safety data will be retained; they contain important product information
- If surplus product must be disposed of, manufacturers' or local and State recommended methods for proper disposal will be followed.

SPILL PREVENTION (Continued)

Product Specific Practices

The following product specific practices will be followed onsite:

Petroleum Products:

All onsite vehicles will be monitored for leaks and receive regular preventive maintenance to reduce the chance of leakage. Petroleum products will be stored in tightly sealed containers which are clearly labeled. Any asphalt substances used onsite will be applied according to the manufacturer's recommendations.

Fertilizers:

Fertilizers used will be applied only in the minimum amounts recommended by the manufacturer. Once applied, fertilizer will be worked into the soil to limit exposure to storm water. Storage will be in a covered shed. The contents of any partially used bags of fertilizer will be transferred to a sealable plastic bin to avoid spills.

Paints:

All containers will be tightly sealed and stored when not required for use. Excess paint will not be discharged to the storm sewer system but will be properly disposed of according to manufacturers' instructions or State and local regulations.

Concrete Trucks:

Concrete trucks will not be allowed to wash out or discharge surplus concrete or drum wash water on the site.

Spill Control Practices

In addition to the good housekeeping and material management practices discussed in the previous sections of this plan, the following practices will be followed for spill prevention and cleanup:

- Manufacturers' recommended methods for spill cleanup will be clearly posted and site personnel will be made aware of the procedures and the location of the information and cleanup supplies.
- Materials and equipment necessary for spill cleanup will be kept in the material storage area onsite. Equipment and materials will include but not be limited to brooms, dust pans, mops, rags, gloves, goggles, kitty litter, sand, sawdust, and plastic and metal trash containers specifically for this purpose.
- All spills will be cleaned up immediately after discovery.
- The spill area will be kept well ventilated and personnel will wear appropriate protective clothing to prevent injury from contact with a hazardous substance.
- Spills of toxic or hazardous material will be reported to the appropriate State or local government agency, regardless of the size.
- The spill prevention plan will be adjusted to include measures to prevent this type of spill from reoccurring and how to clean up the spill if there is another one. A description of the spill, what caused it, and the cleanup measures will also be included.
- Mr. Doe, the site superintendent responsible for the day-to-day site operations, will be the spill prevention and cleanup coordinator. He will designate at least three other site personnel who will receive spill prevention and cleanup training. These individuals will each become responsible for a particular phase of prevention and cleanup. The names of responsible spill personnel will be posted in the material storage area and in the office trailer onsite.

POLLUTION PREVENTION PLAN CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

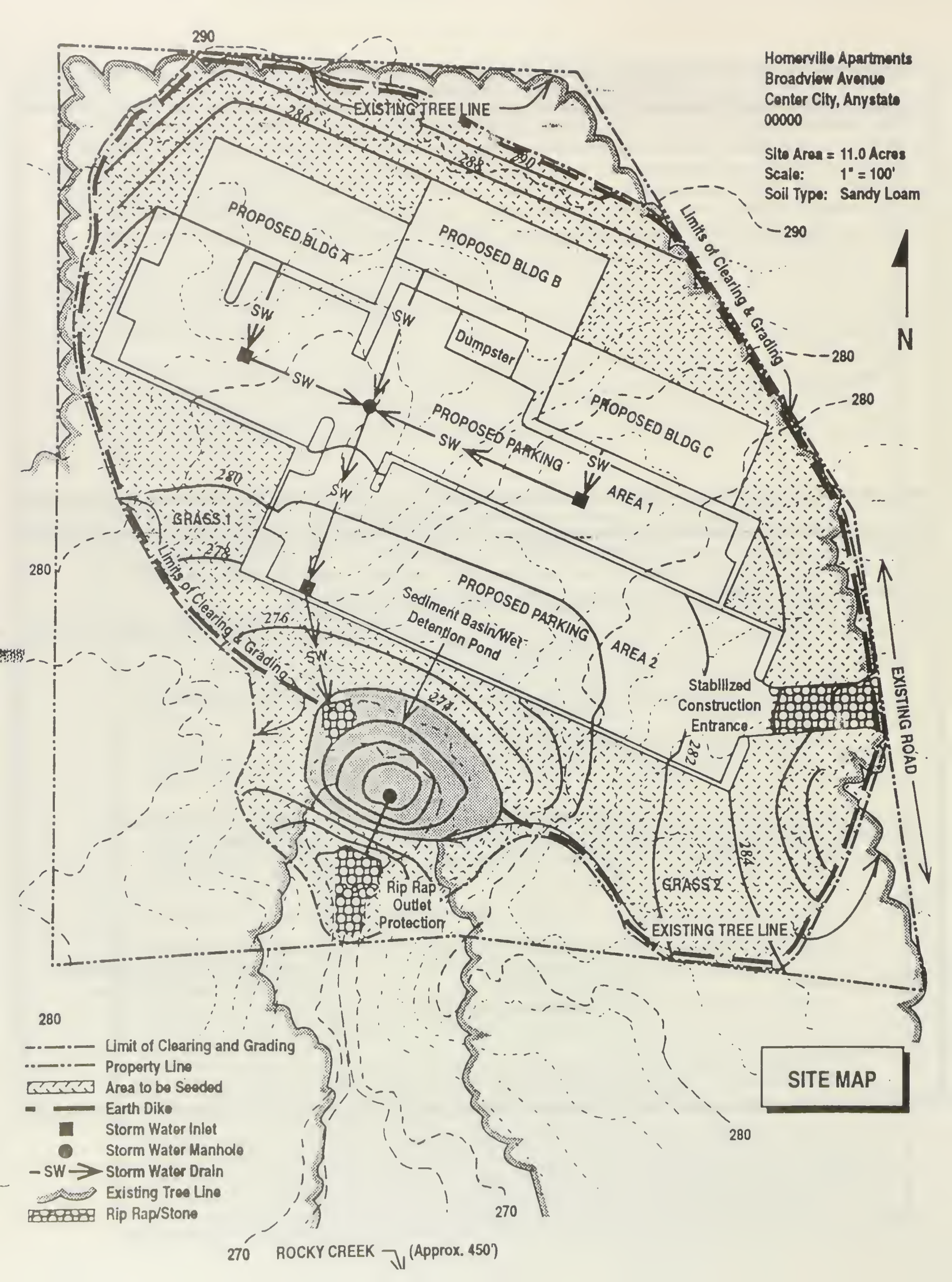
Signed:_____
John R. Quality,
President
Quality Associates

Date:_____

CONTRACTOR'S CERTIFICATION

I certify under penalty of law that I understand the terms and conditions of the general National Poilutant Discharge Elimination System (NPDES) permit that authorizes the storm water discharges associated with industrial activity from the construction site identified as part of this certification.

Signature	For	Responsible for
_____ Joseph Contractor, President Date:_____	Center City Const., Inc. 21 Elm Street Center City, Any State 00000 (123) 399-8765	General Contractor
_____ John Planter Vice President of Construction Date:_____	Green Grass, Inc. 4233 Center Road Outerville, Any State 00001 (123) 823-5678	Temporary and Permanent Stabilization
_____ Jim Kay, President Date:_____	Dirt Movers, Inc. 523 Lincoln Ave. Outerville, Any State 00001 (123) 823-8921	Stabilized Construction Entrance, Earth Dikes, Sediment Basin


Homerville Apartments
Broadview Avenue
Center City, Anystate
00000
Site Area = 11.0 Acres
Scale: 1" = 100'
Soil Type: Sandy Loam
N
EXISTING TREE LINE
PROPOSED BLDG A
PROPOSED BLDG B
PROPOSED BLDG C
Dumpster
PROPOSED PARKING
AREA 1
AREA 2
GRASS 1
GRASS 2
Limits of Clearing & Grading
Sediment Basin/Wet Detention Pond
Stabilized Construction Entrance
EXISTING ROAD
Rip Rap Outlet Protection
SW
290
288
286
280
278
276
274
282
284
270
Limit of Clearing and Grading
Property Line
Area to be Seeded
Earth Dike
Storm Water Inlet
Storm Water Manhole
Storm Water Drain
Existing Tree Line
Rip Rap/Stone
ROCKY CREEK (Approx. 450')
SITE MAP

GENERAL DISCHARGE PERMIT FOR

STORM WATER ASSOCIATED WITH CONSTRUCTION ACTIVITY

Storm Water GDP
Permit No.: MT-R100000

GENERAL DISCHARGE PERMIT FOR

STORM WATER ASSOCIATED WITH CONSTRUCTION ACTIVITY

MONTANA DEPARTMENT OF HEALTH
AND
ENVIRONMENTAL SCIENCES

AUTHORIZATION TO DISCHARGE UNDER THE

MONTANA POLLUTANT DISCHARGE ELIMINATION SYSTEM

In compliance with Section 75-5-101 et seq., MCA, ARM 16.20.1301 et seq., and ARM 16.20.601 et seq., applicants with an authorization letter for this "Storm Water Associated with Construction Activity General Discharge Permit," are permitted to discharge storm water resulting only from construction activities, to state waters in accordance with effluent limitations, monitoring requirements and other conditions set forth in Parts I, II, III and IV hereof.

This permit shall become effective on the date of issuance.

This permit shall expire at midnight, August 31, 1997.

FOR THE MONTANA DEPARTMENT OF HEALTH
AND ENVIRONMENTAL SCIENCES

Frederick C. Shewman

Frederick C. Shewman, P. E., Supervisor
Permits/Groundwater Section
Water Quality Bureau
Environmental Sciences Division

Dated this 17th day of November, 1992

PREAMBLE

The purpose of this preamble is to provide the permit holder with some understanding of what is required for compliance under this permit.

The basic principle of the permit is to identify areas or activities which may contribute pollutants to surface waters and consider practical methods to reduce such pollutants from your operation. The degree of pollution control needed will vary depending on the site and the situation. For example, if you are constructing a road on perfectly flat ground in which there are no surface waters in close proximity to your activities, the potential to cause pollution of surface water is minimal and only minimal erosion controls would be expected. On the other hand, if you are constructing a highway and there are several stream drainages, wetlands, etc. in close proximity to your project, very comprehensive and complete pollution controls would be expected.

The major pollutant that will be a problem for construction sites will be sediment discharges from increased erosion. If the project will impact a "live" water body (a stream , lake, reservoir, etc. that has water year round), you **must** insure that sediment does not reach state waters by using appropriate erosion control practices. The discharge of discolored water could cause a violation of this permit. Adequate erosion control practices must also be used to prevent sediment discharges to wetlands, riparian areas, and ephemeral drainages.

Other pollutants most likely to be a problem at construction sites are fuels, lubricating oils, construction materials, fertilizers and pesticides. The bottom line is store these materials properly and well away from surface waters, to prevent spills of these materials, and by not dumping in the first place.

The basic requirements of the "Storm Water Erosion Control Plan" are provided in Part II.

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I. COVERAGE UNDER THIS PERMIT

A. Permit Area

The permit applies to all areas of the state of Montana except Indian Reservations.

B. Sources Covered Under This Permit

The permit covers construction activities including clearing, grading, or excavating which will result in the disturbance of a total of five (5) or more acres or the disturbance of greater than one acre if located less than one hundred (100) feet from state waters. All discharges shall be in accordance with the "approved" erosion control plan and the provisions of this permit.

Any other direct waste discharge to public waters is prohibited unless covered by another MPDES permit.

This permit does not relieve the permittee from responsibility for compliance with any other applicable federal, state, or local law, rule, standard, ordinance, order, judgement, or decree.

C. Application Procedures

1. **Application Due Dates:** At least thirty (30) days prior to construction taking place, or by October 1, 1992, whichever is later, the permittee (see definitions) of the construction activity shall submit an application as provided by the Department.

2. **Application Form:** The application form requires, at a minimum, the following information:

    1) Name and address of contractor;
    2) Construction site address and name of owner/operator (for MDT projects, project number and designation);
    3) Contact person and telephone number;
    4) The nature of the construction activity;
    5) Total area of the site and the area that will be disturbed;
    6) Site location (County, Township, Range, Section, 1/4 Section);

7) The best management practices to be used during construction to control sediment and erosion.
8) The best management practices to be used to control pollutants in storm water after construction is completed;
9) Name of receiving water and indicate if discharging to a municipally owned storm sewer;
10) A detailed erosion control plan must be approved prior to construction taking place;
11) A site map and a drainage map (with drainage patterns indicated).

3. **Application Submittal:** A signed state application form shall be submitted to:

Montana Department of Health and Environmental Sciences
Water Quality Bureau, Room A206
1400 Broadway
PO Box 200901
Helena, MT 59620-0901

4. **Authorization to Discharge:** Construction activities covered under this permit are authorized to begin construction and implement the "approved" erosion control plan in accordance with the permit upon receipt of an authorization under the general permit issued by the Department.

PART II.

II. SPECIAL CONDITIONS

A. Prohibitions on Non-storm Water Discharges

All discharges covered by this permit shall be composed entirely of storm water. Discharges of material other than storm water runoff must be in compliance with an MPDES permit (other than this permit) issued for the discharge.

B. Releases in Excess of Reportable Quantities

The discharge of hazardous substances or oil in the storm water discharge(s) from construction activities shall be minimized in accordance with the applicable Erosion Control Plan for the project. Where a release

containing a hazardous substance or oil in an amount equal to or in excess of a reportable quantity established under either 40 CFR 110, 40 CFR 117 or 40 CFR 302, occurs during a 24 hour period:

(1) The person in charge of the construction project is required to notify the Nation Response Center (800-424-8802) and the Water Quality Bureau (444-5338) as soon as he or she has knowledge of the discharge;

(2) The permittee shall submit, within 7 calendar days of knowledge of the release, a report with a description of the release (including the type and estimate of the amount of material released), the circumstances leading to the release, and steps to be taken to remediate environmental contamination associated with the release to the Montana Department of Health and Environmental Sciences at the address provided in Part III.C.; and

(3) The Storm Water Erosion Control Plan described below must be modified within 7 calendar days of knowledge of the release to: provide a description of the release and the circumstances leading to the release; and to identify and provide for the implementation of steps to prevent the reoccurrence of such releases and to respond to remediation of such releases.

C. Storm Water Erosion Control Plan

Prior to commencement of construction or by October 1, 1992, whichever occurs later, the permittee shall prepare and implement an **Erosion Control Plan.** The objective of the plan is to minimize the erosion of disturbed land during the construction and post construction activities and to minimize pollutants such as fuels, oil, grease, fertilizer, pesticides, concrete truck washout, etc. from discharging to surface waters.

The plan shall:

(a) be submitted to the Department 30 days prior to construction or by October 1, 1992, whichever occurs later, for approval;

(b) be signed in accordance with the signatory requirement in Part IV.G.;

(c) a copy shall also be maintained at the construction site in accordance with part III.D. of this permit; and

(d) provide for compliance with the terms and schedule of the plan once approved by the Department and updated as appropriate.

1. a) The contractor of a construction project covered by this permit shall maintain a copy of the erosion control plan on-site and a copy of the plan shall be available upon request to the owner, the Montana Department of Fish, Wildlife and Parks, local officials, and a municipal operator if the discharge is through a municipal system.

b) The plan must be approved by the Department and implemented at the beginning and throughout the lifespan of the project. The Department may notify the permittee at any time that the plan does not meet one or more of the minimum requirements of this part. After such notification from the Department, the permittee shall make changes to the plan and submit a written certification that the requested changes have been made to the Department. Unless otherwise provided by the Department, the permittee shall have 7 days after such notification to make the required changes.

c) The permittee shall amend the plan whenever there is a change in design, construction, operation, or maintenance, which has a significant effect on the potential for the discharge of pollutants to waters of the state or if the erosion control plan proves to be ineffective in achieving the general objectives of controlling pollutants in storm water discharges associated with construction activity.

2. The plan may include the use of sediment basins, berms, barriers, filter strips, covers, diversion structures, seeding, sodding, and/or other control structures or best management practices (BMPs). Any plan which requires engineered structures, such as detention ponds or diversion structures, or which is prepared for a construction activity which includes 20 acres or more in total land disturbance, shall be prepared by a registered

professional engineer. The erosion control plan shall include at least the following items:

a. Site Description. Each plan shall, at a minimum, provide a description of the following:

(1) The nature of the construction activity, including a proposed timetable for major activities;

(2) Estimates of the total area of the site, and all other sites if a phased development project, and the area of the site that is expected to undergo clearing, excavation, and/or grading;

(3) A site map indicating areas of total development and, as a minimum, all areas of soil disturbance, areas of cut and fill, drainage patterns and approximate slopes anticipated after major grading activities, areas used for the storage of soils or wastes, location of all erosion control facilities or structures and areas where vegetative practices are to be implemented, the location of impervious structures (including buildings, roads, parking lots, outdoor storage areas, and etc.) after construction is completed, springs, wetlands and other surface waters, and the boundary of 100-year flood plains, if determined;

(4) The nature of fill material to be used, the existing soils located at the site, and the erodibility of such soils: and

(5) The names of the receiving water(s) and the size, type and location of each outfall or, if the discharge is to a municipal separate storm sewer, a letter of approval from the municipality which authorizes use of the storm sewer and the location of any storm sewer discharge to public waters.

b. Controls

Each operator covered by this permit shall develop, as part of the erosion control plan, a description of controls appropriate for the site and shall implement such controls. The following minimum
components shall be addressed along with a schedule for implementation, unless approved otherwise in writing by the permit issuing agency:

(1) A description, including a schedule of implementation, of stabilization practices designed to preserve existing vegetation where practicable and re-vegetate open areas as soon as practicable after grading or construction. In developing vegetative practices, the operator shall consider: temporary seeding, permanent seeding, mulching, sod stabilization, vegetative buffer/filter strips, grassed waterways, erosion control blankets and tree and shrub planting.

(2) A description of structural practices which indicates how, to the degree practicable, the permittee will divert flows from exposed soil, store flows, or otherwise limit runoff from exposed areas of the site. In developing structural practices, the operator shall consider the appropriateness of: straw bale dikes, silt fences, earth dikes, brush barriers, drainage swales, check dams, subsurface drains, pipe slope drains, rock outlet protection, drain inlet and outlet protection, temporary drain diversions, sedimenttraps, temporary sediment basins, infiltration trenches or basins, and retaining walls. None of the temporary control structures, including silt fences and straw bale dikes, shall be removed until permanent vegetation and site stabilization has taken place.

(3) For sites in which the tracking of sediment onto public or private roads during the wet season (November - June) will be a problem, the site shall have graveled access entrance and exit drives and parking areas. All unpaved roads on the site carrying more than 25 vehicle trips per day shall be graveled.

(4) When trucking saturated soils from the site, either tight trucks shall be used or loads shall be required to drain until drippage has been reduced to less than 1 gallon per hour before leaving the site.

3. Visible or measurable erosion which leaves the construction site is prohibited. Visible or measurable erosion is defined as:

a. Deposits of mud, dirt, sediment or similar

material exceeding 1/2 cubic foot in volume in any area of 100 square feet or less on public or private streets, adjacent property, or into the storm and surface water system, either by direct deposit, dropping, discharge, or as a result of the action of erosion; or

b. Evidence of concentrated flows of water over bare soils; turbid or sediment laden flows; or evidence of on-site erosion such as rivulets on bare soil slopes, where the flow of water is not filtered or captured on the site using the techniques in the approved erosion control plan; or

c. Earth slides, mud flows, earth sloughing, or other earth movement which leaves the construction site.

4. If any visible or measurable quantities of sediment leave the site because of the failure of the erosion control facilities, the sediment shall be immediately (within 24 hours) cleaned up and placed back on the site or disposed of in a manner approved by the Department. Under no conditions shall the sediment be washed into the storm sewers or drainageways.

5. All non-regulated wastes composed of building material must be removed from the site or disposed in approved disposal facility. Building material wastes or unused materials may not be dumped or discharged at the site. The State Solid Waste Program should be contacted concerning proper disposal of waste materials.

6. A description of measures to control pollutants in storm water discharges that will occur after construction operations have been completed shall be addressed in the erosion control plan. Such practices may include: storm water detention structures (including wet ponds); storm water retention structures; flow attenuation by use of open vegetated swales and natural depressions; and infiltration of runoff on site.

PART III.

III. MONITORING, RECORDING AND REPORTING REQUIREMENTS

A. Monitoring Requirements

During the period beginning immediately and lasting through the duration of the permit, the permittee is authorized to discharge from outfall(s) as required within the erosion control plan. Such discharges shall be limited and monitored by the permittee as specified below:

1. All erosion control facilities shall be inspected by or under the direction of the permittee at least once every seven calendar days and within 24 hours after any storm event of greater than 0.5 inches of rain per 24 hour period.

2. During stormy periods or periods of snow melt when runoff occurs daily, all erosion control facilities shall be inspected by or under the direction of the permittee daily.

3. Storm water runoff discharges shall be visually monitored at the above frequency to evaluate the effectiveness of the pollution control facilities or practices. If any measurable quantities of sediment are leaving the property, corrective action shall be taken within 24 hours to reduce the discharge of sediments.

B. Recording Requirements

The operator shall keep a record of inspections, the date and time inspected, and the name of the person performing the inspection. Uncontrolled releases of mud or muddy water or measurable quantities of sediment found off the site shall be recorded with a brief explanation as to the measures taken to prevent future releases as well as any measures taken to clean up the sediment that has left the site. This record shall be made available to the Department upon request and shall be signed in accordance with the signatory and certification requirements of Parts IV.G. and IV.H.

C. Reporting Requirements

If the construction activity lasts more than 12 months, an annual inspection of the site shall be conducted to identify areas which may be contributing pollutants to storm water discharges. The annual inspection report shall be submitted to the Department 30 days after the inspection has taken place. Inspection results shall be reported in writing to the Department address below:

Montana Department of Health and Environmental Sciences
Water Quality Bureau
1400 Broadway, A-206
P. O. Box 200901
Helena, MT 59620-0901
Phone (406) 444-2406

D. Records Retention

All records and information resulting from the monitoring activities required by this permit shall be retained for a minimum of three (3) years, or longer if requested by the Department.

E. Noncompliance Reporting

If, for any reason, the permittee does not comply with or will be unable to comply with any condition specified in this permit, the permittee shall notify as soon as possible by phone and provide the Department with the following information, in writing, within five (5) days of becoming aware of such condition:

a. A description of the discharge and cause of noncompliance; and

b. The period of noncompliance, including exact dates and times; or, if not correct, the anticipated time the noncompliance is expected to continue, and steps being taken to reduce, eliminate and prevent recurrences of the non complying discharge.

F. Penalties for Tampering

The Montana Water Quality Act provides that any person who falsifies, tampers with, or knowingly renders inaccurate, any monitoring device, method or practice required to be maintained under this permit shall, upon

conviction, be punished by a fine of not more than $25,000 per day of violation or imprisonment for not more than 1 year, or both.

PART IV.

IV. STANDARD PERMIT CONDITIONS

A. Duty to Comply

The permittee must comply with all conditions of this permit. Any permit noncompliance constitutes a violation of the Act and is grounds for enforcement action; for permit termination, revocation and reissuance, or modification; or for denial of a permit renewal application. The permittee shall give the Department advance notice of any planned changes at the permitted facility or of an activity which may result in permit noncompliance.

The Montana Water Quality Act (MCA 75-5-631) and the Federal Clean Water Act (section 309) provide significant penalties for any person who violates a permit condition. Any person who violates any condition of this permit is subject to a civil penalty not to exceed $25,000 per day of such violation, as well as any other appropriate sanction provided by section 309 of the Clean Water Act.

B. Continuation of the Expired Permit

An expired general permit continues in force and effect until a new general permit is issued. Only those facilities authorized to discharge under the expiring permit are covered by the continued permit.

C. Need to Halt or Reduce Activity not a Defense

It shall not be a defense for a permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

D. Duty to Mitigate

The permittee shall take all reasonable steps to minimize or prevent any discharge in violation of this permit which has a reasonable likelihood of adversely affecting
human health or the environment.

E. Duty to Provide Information

The permittee shall furnish to the Department, within a reasonable time, any information which the Department may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit, or to determine compliance with this permit. The permittee shall also furnish to the Department, upon request, copies of records required to be kept by this permit.

F. Other Information

When the permittee becomes aware that it failed to submit any relevant facts in a permit application, or submitted incorrect information in a permit application or any report to the Department, it shall promptly submit such facts or information.

G. Signatory Requirements

All applications, reports or information submitted to the Department shall be signed and certified.

1. All permit applications shall be signed as follows:

a. For a corporation: by a responsible corporate officer;

b. For a partnership or sole proprietorship: By a general partner or the proprietor, respectively;

c. For a municipality, State, Federal, or other public agency: by either a principal executive officer or ranking elected official.

2. All reports required by the permit and other information requested by the Department shall be signed by a person described above or by a duly authorized representative of that person. A person is a duly authorized representative only if:

a. The authorization is made in writing by a person described above and submitted to the Department, and,

b. The authorization specified either an individual or a position having responsibility for the overall operation of the regulated facility or activity, such as the position of plant manager, operator of a well or a well field, superintendent, position of equivalent responsibility, or an individual or position having overall responsibility for environmental matters for the company. (A duly authorized representative may thus be either a named individual or any individual occupying a named position.)

3. Changes to authorization. If an authorization under paragraph IV.G.2. is no longer accurate because a different individual or position has responsibility for the overall operation of the facility, a new authorization satisfying the requirements of paragraph IV.G.2. must be submitted to the Department prior to or together with any reports, information, or applications to be signed by an authorized representative.

H. Certification

Any person signing a document under this section shall make the following certification:

"I certify under penalty of the law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

I. Penalties for Falsification of Reports

The Montana Water Quality Act provides that any person who knowingly makes any false statement, representation, or certification in any record or other document submitted or required to be maintained under this permit, including monitoring reports or reports

of compliance shall, upon conviction be punished by a fine of not more than $25,000 per day, or by imprisonment for not more than 1 year per violation, or by both.

J. Oil and Hazardous Substance Liability

Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties to which the permittee is or may be subject under Section 311 of the Clean Water Act.

K. Property Rights

The issuance of this permit does not convey any property rights of any sort, nor any exclusive privileges, nor does it authorize any injury to private property nor any invasion of personal rights, nor any infringement of federal, state or local laws or regulations.

L. Severability

The provisions of this permit are severable, and if any provision of this permit, or the application of any provision of this permit to any circumstance, is held invalid, the application of such provision to other circumstances, and the remainder of this permit, shall not be affected thereby.

M. State Laws

Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties established pursuant to any applicable State law or regulation under authority preserved by section 510 of the Act.

N. Proper Operation and Maintenance

The permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the permittee to achieve compliance with the conditions of this permit and with the requirements of erosion control plans. Proper operation and maintenance also includes adequate laboratory controls

and appropriate quality assurance procedures. Proper operation and maintenance requires the operation of backup or auxiliary facilities or similar systems, installed by a permittee only when necessary to achieve compliance with the conditions of the permit.

O. Inspection and Entry

The permittee shall allow the Department or the Regional Administrator, or authorized representative thereof, upon the presentation of credentials and other documents as may be required by law, to:

1. Enter upon the permittee's premises where a regulated facility or activity is located or conducted, or where records must be kept under the conditions of this permit;

2. Have access to and copy, at reasonable times, any records that must be kept under the conditions of this permit;

3. Inspect at reasonable times any facilities, equipment (including monitoring and control equipment), practices, or operations regulated or required under this permit; and,

4. Sample or monitor at reasonable times, for the purpose of assuring permit compliance, any substances or parameters at any location.

P. Permit Actions

This permit may be modified, revoked and reissued, or terminated for cause. The filing of a request by the permittee for a permit modification, revocation and reissuance, or termination, or notification of planned changes or anticipated noncompliance, does not stay any permit condition.

Q. Reopener Provision

If there is evidence indicating potential or realized impacts on water quality due to any storm water discharge associated with construction activity covered by this permit, the owner or operator may be required to obtain an individual permit or an alternate general permit or the permit may be modified to include different limitations and/or requirements.

R. Notice of Termination

Where a site has been finally stabilized or where the operator or contractor at a site changes, the operator or contractor of the construction site may submit a Notice of Termination that is signed in accordance with Part IV.G. The Notice of Termination shall include the following information:

1. The mailing address of the construction site. Where a mailing address for the site is not available, the location of the site must be described as County, Township, Range, Section, and 1/4 Section;

2. The name, address and telephone number of the owner and contractor(s) involved with the site;

3. The MPDES permit number for the construction site;

4. An indication of whether the site has been permanently stabilized or the contractor(s) of the project has changed; and

5. The Notice of Termination must be certified and signed in accordance with Part IV.G. and IV.H.

The Notice of Termination shall be sent to the following address:

Montana Department of Health and Environmental Sciences
Water Quality Bureau, Room A206
1400 Broadway
P. O. Box 200901
Helena, MT 59620-0901

S. Definitions

1. The "Act" means the Federal Clean Water Act.

2. "Best Management Practices" ("BMPs") means schedule of activities, prohibition of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of state waters. BMPs also include treatment requirements, operating procedures, and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.

3. "Bypass" means the intentional diversion of waste streams from any portion of a treatment facility or a BMP.

4. The "Department" means the Montana Department of Health and Environmental Sciences.

5. "Permittee" for construction activity means both the owner of the property and the contractor(s) conducting the construction activity. For the purposes of this permit, the owner and the contractor(s) will be co-permittees under the storm water general permit.

6. The "receiving water" is the river, stream, lake, etc. which receives the discharge from your site.

7. "Severe Property Damage" means substantial physical damage to property, damage to treatment facilities which causes them to become inoperable, or substantial and permanent loss of natural resources which can reasonably be expected to occur in the absence of a bypass. Severe property damage does not mean economic loss caused by delays in production.

8. "Storm Water" means storm water runoff, snow melt runoff, and surface runoff and drainage.